The Middle Triassic Megafossil Flora of the Basin Creek Formation, Nymboida Coal Measures, New South Wales, Australia. Part 2. Filicophyta

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Ferns and fern-like foliage comprise 25% of the collections from the Middle Triassic Basin Creek Formation at Nymboida. The diverse fern flora ranges in size from tiny forms a few centimetres in height, to large ferns with fronds equalling in length those of the largest extant treeferns. This paper describes ferns preserved as fertile fronds, fertile fronds with closely associated sterile fronds or sterile fronds of known affinities. The Marattiales is represented by eight taxa, the Osmundales by two taxa, the Filicales by three taxa and one taxon is of uncertain position. Ten new taxa are erected for fertile fronds and four species are ascribed to previously published material. New forms include *Rhinipteris walkomii* sp. nov., *Asterotheca trullensis* sp. nov., *A. nymboidensis* sp. nov., *A. chevronervia* sp. nov., *A. diameson* sp. nov., *Herbstopteris colliveri* (Herbst) gen. et comb. nov., *Todites parvum* sp. nov., *Osmundopsis scalaris* sp. nov., *Hausmannia reticulata* sp. nov. and *Nymbofelicia aggregata* gen. et sp. nov. A paper in preparation will describe many additional morpho-taxa of sterile fern fronds and fern-like foliage which cannot be systematically classified.

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KEYWORDS: Palaeobotany, Middle Triassic flora, Nymboida Coal Measures, Filicophyta, megafossil fertile ferns.

INTRODUCTION

In this second part of a series on the Nymboida Flora, ferns are described which are known from fertile fronds, fertile fronds with closely associated sterile fronds or sterile fronds that can be confidently assigned to known fern taxa. Ten new taxa are erected for fertile specimens and four species are ascribed to previously described material. Numerous other specimens comprising sterile fern-like foliage of doubtful affinities will be described in a future part of this series. Fossil ferns have been reported previously from the Nymboida Coal Measures by de Jersey (1958), McElroy (1963), Flint and Gould (1975), Retallack (1977), Retallack et al. (1977), Herbst (1977a, 1977b, 1978) and Webb (1982, 1983, 2001).

Details of the Coal Mine and Reserve Quarries which were the source of the Nymboida Flora are provided in Holmes (2000). The present collections reveal further evidence in the shales and siltstones of autochthonous and semi-autochthonous

assemblages derived from levee forests, floodplains and swamps somewhat similar to those reconstructed for the Molteno Formation of South Africa by Anderson et al. (1998) and MacRea (1999). The high energy sandstones and grits contain allochthonous assemblages of point bar and riverbank vegetation (Anderson and Anderson 1983; Retallack 1977). The Nymboida Sub-Basin palaeoenvironment was reconstructed by Retallack (1977) as a riverine floodplain. The rarity of exposed red-bed horizons in the Nymboida quarries suggests that a high water table prevailed during most of the period of deposition (Retallack et al. 1996). On the basis of the clay-mineral content in many of the sediments, McElroy (1963) suggested that the Sub-Basin represented a ponded environment.

Ferns and fern-like foliage are common in most fossiliferous horizons at these two quarries. In my collections made over the last 35 years, ferns and fernlike material comprise approximately 25% of the catalogued material. Due to preservation, collecting and other biases, this figure does not necessarily represent the proportion of ferns in the living vegetation. In size, the Nymboida ferns range from tiny plants measuring only a few centimetres in length to fronds three metres or more long which equal in size some of the largest extant southern ferns such as *Angiopteris, Cyathea* and *Dicksonia*. Despite the climatic implications inferred by the palaeolatitude c. 60°S for the Nymboida Sub-Basin at the time of its deposition (Anderson and Anderson 1983; Scotese 1994)) the flora suggests a moist temperate climate. The number and diversity of ferns in the present collection is a remarkable demonstration of the recovery of this group of plants following the catastrophic end-Permian extinction event and the subsequent "coal gap" during the Early Triassic (Retallack et al. 1996).

The classification adopted in this paper broadly follows that of Boureau (1975) and Meyen (1987). As noted by Meyen (1987), "the classification and systematics of the ferns is in a state of flux and in the fossil state where often only dispersed portions of fronds are available, the difficulties are even greater". From my extensive Nymboida collections, it has been possible to link some sterile and fertile fronds. On rare occasions, these have been found found attached to the same frond. This paper and another in preparation will provide, for the first time, a comprehensive picture of the diversity of ferns occurring in Australia during the Middle Triassic. Due to the great dissimilarities between the Gondwana and Northern Hemisphere floras during the Middle Triassic (Archangelsky 1965; Meyen 1987), at least at species level, the Nymboida taxa are compared in most cases only with other Gondwana material.

This series of papers, which deals only with the descriptive taxonomy of the plants present in the Nymboida Flora, will provide a reference base for future taphonomic, palaeoecological and allied studies.

The Nymboida specimens were collected mostly from fallen blocks that had been blasted or mechanically excavated from the vertical quarry faces. Thus, the exact horizons from which the material originated is, in most cases, unknown. I have not tried to recreate vegetational palaeodemes in the sense of Anderson and Anderson (1983). Many blocks reveal two or more different taxa, so it may be possible to match matrices and taxa preserved to reconstruct plant associations such as those of Anderson et al (1998) and MacCrea (1999) for the Molteno Flora. As noted by Holmes (2000) the Nymboida fossil flora provides a unique window onto the mozaic of plant communities and successions that occupied an area of 2.5 hectares during a brief period of geological time c. 237 million years ago (Retallack et al. 1993).

Most specimens are preserved as carbonaceous compressions in which the gross morphology is from well- to exquisitely preserved. However spores and cellular details have been destroyed by a tectonic heating event during the Cretaceous Period (de Jersey 1958; Hennelly, in McElroy 1963; Russell 1994).

The institutions holding Nymboida fossil plant material are listed as – AM, Australian Museum, Sydney, NSW; UNE, University of New England, Armidale, NSW; QM, Queensland Museum, Brisbane, Queensland.

Specimens on the Figures are illustrated at natural size unless otherwise stated. Figures are located in a separate section at the back of this paper.

SYSTEMATIC PALAEOBOTANY

Phylum Filicophyta
Order Marattiales
Family Marattiaceae
Genus *Ogmos* Webb 1983

Ogmos adinus Webb 1983, p.364.
Figure 1A-C

1924 *Taeniopteris* (?*Danaeopsis*) *crassinervis* Walkom, Pl. 18, Figs 1 and 2 only.
1975 *Taeniopteris crassinerva* Flint and Gould, Pl. 2, Figs 7, 8.
1983 *Ogmos adinus* Webb, p.364, Figs 2-10.

Description

Fronds simple, large, to 400 mm long and 80 mm wide, elongate-spathulate to narrow elliptical, margin entire, midrib broad to 10 mm wide near base, but leaf base not known. Apex acuminate to broad obtuse or emarginate. Lateral venation very coarse, straight, attached at c. 80°-90° in basal half then becoming slightly more acute towards the apex. Veins simple or rarely once-forked; 5 to 12 per 10 mm.

Material

AMF113382- 113386, UNEF14125-6. Coal Mine Quarry, Nymboida.

Discussion

Ogmos adinus is a rare element at Nymboida having been collected on three occasions only. In one small shale lens the numerous leaves lying in close proximity or overlapping (Fig. 1B) suggested a growth form similar in life to that of the extant *Asplenium nidus*. The fertile material of *Ogmos adinus* from the Bryden Beds of the Esk Trough (Webb 1983) showed sporangia forming continuous single file rows from the midrib to the margin and parallel with the lateral veins. At Nymboida there are no fertile leaves present, but the size and venation pattern of the sterile leaves is closely similar to that of the sterile leaves illustrated by Webb (1983).

Genus *Marantoidea* Jaeger 1827
Type species *Marantoidea arenacea* Jaeger 1827

Marantoidea acara Webb 2001
Figs 2A; 3A,B.

2001 *Marantoidea acara* Webb (this volume)

Description

Fronds are relatively large (Fig. 2A), with a rachis 6-7 mm wide from which opposite to subopposite pinnae diverge at angles of 45°-60°, 3-5 cm. apart. Individual pinnae are at least 18 cm long and 20-30 mm wide and taper gradually to an acute apex. At the base of each pinna the upper pinna margin is markedly contracted, whereas the lower margin is decurrent on the rachis. Midveins of pinnae are to 2 mm wide; secondary veins diverge at very acute angles but curve away almost immediately and run fairly straight and parallel to reach the margin at an angle of 60°-80° to the midrib. Most secondary veins fork once close to the midrib, rarely a second time; then anastomose with an adjacent vein near the margin, but this character is difficult to observe. Density of venation varies

from 12-14 veins per 10 mm in sterile fronds. In fertile material the veins are denser and vary from 18-20 per 10 mm.

On fertile pinnae (Figs 3A, B) the underside of the leaf is covered with small (0.2 x 0.15 mm) ellipsoidal sporangia, with their long axes perpendicular to the lateral venation. Each sporangium has a prominent longitudinal slit, and no apical depression is visible. The sporangia are arranged in rows roughly parallel to the venation, but are not obviously differentiated into sori; spacing between rows is fairly uniform.

Material

AMF113387-113390, AMF113449. Coal Mine Quarry, Nymboida.

Discussion

The Nymboida material, which comprises both sterile and fertile fronds, complements that from the type locality in the Esk Trough, Queensland and was examined by Webb (2001) during his revision of the genus *Marantoidea*.

Genus *Rhinipteris* Harris 1931
Type species *Rhinipteris concinna* (Presl) Harris 1931, p.58.

Rhinipteris walkomii Holmes sp. nov.
Figures 4A,B; 5A-C.

Diagnosis

Large dimorphic fronds; sterile portions tripinnate, fertile portions bipinnate, with both fertile and sterile pinnules sometimes occurring on same pinna rachis. Sterile pinnules with 4-6 well spaced lateral veins. Fertile pinnules with length to width ratio of 3-4:1; abaxial surface completely covered by synangia aligned in parallel rows both longitudinally and transversely.

Description

A fern with very large fronds estimated to be more than 3 metres in length; primary rachis to 5 cm wide near base; longitudinally striated (Fig. 5A). Fronds sterile and tripinnate or fertile and bipinnate; sometimes with sterile and fertile pinnae occurring on the same frond (Fig. 4A). Primary sterile pinnae bipinnate, broad-lanceolate to 100 mm long and 50 mm wide (Fig. 4B, 5A), overlapping adjacent pinnae; attached alternately to the broad primary rachis; proximal pinnae recurved; in the midportion of frond attached at right angles and at a decreasing angle distally. Secondary sterile pinnae alternate, linear, to 50 mm long and 8 mm wide; tapering distally and becoming pinnatifid; attached at 75°-90°. Proximal pinnules alternate, separated to a broad base; sometimes overlapping, oblong to circular, 2-2.5 mm wide and 3-6 mm long; attached at c. 60°, apex obtuse; becoming pinnatifid distally; midvein decurrent then decurving and running straight to pinnule apex; four to six lateral veins leave midvein but the details are usually obscured due to the thick texture of the pinnule lamina. Fertile pinnae once pinnate, linear, to 50 mm wide and to 200 mm long. The tertiary sterile pinnules have coalesced to form large coherent synangia-bearing fertile pinnules which are alternate to subopposite, broad-linear, 5-8 mm wide and 20-22 mm long, apex obtuse, sometimes slightly falcate (Figs. 4A, 5B,C). The pinnules are closely spaced or overlapping, attached at a high angle to pinna rachis. Each fertile pinnule bears rows of synangia, four on either side of the midvein, which completely cover the lamina surface except over the midvein. They are arranged in straight parallel rows both longitudinally and transversely. The synangia are closely spaced, about 1 mm in diameter, but the finer details of the sporangia are not preserved on present material.

Holotype

AMF113393. Syntypes AMF113394-113399, AMF113461. Australian Museum, Sydney.

Type Locality

Reserve Quarry, Nymboida, Basin Creek Formation, Nymboida Coal Measures.

Name Derivation

walkomii - for my mentor, the late Dr A.B.Walkom, eminent Australian palaeobotanist, councillor for 53 years and editor for 39 years of the Linnean Society of New South Wales (Vallance 1975).

Discussion

This is one of the larger ferns in the Nymboida collection but has been collected only from a single horizon at the Reserve Quarry. That horizon has yielded two other large ferns; *Asterotheca chevronervia* described below and a fern known only from trimorphic sterile fronds which will be described in the next part of this series. The dimorphic form of the fertile and sterile portions of the fronds of *Rhinipteris walkomii* and the arrangement of the sporangia on the fertile pinnules distinguishes this fern from all others previously recorded from Gondwana Triassic assemblages.

The present material is placed in *Rhinipteris* on the basis of the close similarity of its fertile pinnules with *R. concinna* (Presl) Harris (Harris 1931, pl.12, fig.1; Boureau 1970, fig.182). The genus was erected by Harris for both sterile and fertile fragments found in close association in the middle of Bed A in the Rhaetic "*Lepidopteris* Beds" of Scoresby Sound, Greenland. *R. walkomii* differs from *R. concinna* by its shorter fertile pinnules and by the regular arrangement of the synangia, both longitudinally and laterally. The reconstruction by Harris of a fertile pinnule (Harris 1931, text fig. 20F- incorrectly labelled *R. nitida*) shows irregular rows of synangia. No venation is preserved on the adaxial surface of fertile pinnules of *R. walkomii* to compare with Harris's figure. The venation on the sterile specimens of *R. walkomii* also is not clear due to the apparent thick texture of the pinnules. Where seen, the lateral veins appear to be more sparse than in *R. concinna*, but there is a wide range of variation, as seen on the individual fragments illustrated by Harris (1931, text figs 20 B-D).

Reinitsia ternerae Herbst et al (1998) from the Upper Triassic of Chile has fertile pinnules bearing two or three rows of synangia on either side of the midrib. *R. ternerae* differs from *Rhinipteris walkomii* by its sterile pinnules which are similar in form to its fertile pinnules, by the broad pinnule midvein and by the synangia being four to six sporangiate.

From the shape and thick texture of the pinnules, sterile pinnae of *R. walkomii* could be confused with *Lepidopteris* spp. but they can be distinguished from that genus by the absence of pinnules on the rachis between the pinnae.

Family Asterothecaceae

Genus *Asterotheca* Presl, in Corda 1845

Type species *A. sternbergii* (Goeppert) Presl, in Corda 1845

Asterotheca is a genus erected for fertile ferns with pecopteroid pinnules which bear a line of adjacent synangia on the abaxial surface between the midvein and the margin. The synangia are composed of groups of sporangia conjoined at the base and dehiscing along an apical suture line. An annulus is absent. The genus includes species from both the northern and southern hemispheres which range in age from Carboniferous to Upper Jurassic. It is most probably not a natural genus. Similar ferns known only from sterile material are often placed in *Pecopteris* (Boureau 1970).

Asterotheca trullensis Holmes sp. nov.
Figure 6A, 7A-C.

1975 *Cladophlebis australis* non (Morris) Seward, Flint and Gould, pl.3, fig. 5.

Diagnosis

Large fern with bi- (? tri-)pinnate fertile fronds. Pinnae long, linear, alternate to subopposite. Fertile pinnules with length to width ratio of c. 2-2.5:1; bearing a non-contiguous row of 12-16 tetra-sporangiate synangia to 0.75 mm in diameter around pinnule lamina, midway between midvein and pinnule margin.

Description

Figure 6A shows three frond segments which may be the primary pinnae of a larger tripinnate frond, or are individual bipinnate fronds arising from a common rhizomatous base. If bipinnate the fronds are estimated to have reached half a metre in length and 16 cm in width. The pinnae are alternate to sub-opposite. Their attachment to the primary rachis is decurved in the proximal pinnae, at right angles in the middle of the frond and becoming more acute towards the frond apex. Pinnae linear, to 90 mm long and 15 mm wide. Fertile pinnules alternate (Fig. 7A, B), attached at 55°-75°, margins parallel, apex rounded; basiscopically decurrent, to 9 mm long and to 4.5 mm wide, but usually less; becoming smaller distally and apically. Length to width ratio of 2-2.5:1. Midvein decurrent, thin, straight. Lateral veins at c. 45°, indistinct, one per synangium, once-forked. Synangia tetrasporangiate, c. 0.75 mm in diameter, c. 12-16 arranged as separate individuals in a single row around pinnule midway between midvein and pinnule margin. Usually one or two more synangia on basiscopic side of pinnule than on acroscopic side. Fossils represented in Figures 7A and 7B are external moulds of the abaxial surface of the pinnae.

No fronds have been found which bear both fertile and sterile pinnules. On gross morphology and close association with fertile fragments, the sterile frond illustrated in Figure 7C is considered to represent the sterile form of *A. trullensis*. Pinnae are alternate, attached at c. 60°, broad-linear to 120 mm long and c. 25 mm wide for 2/3 their length then tapering distally to an acute apex. The sterile pinnules are similar in size but slightly more falcate than fertile pinnules with a length to width ratio of c. 2.5:1, attached alternately to the pinna rachis. The midrib is distinct, continuing almost to pinnule apex. Seven to ten pairs of lateral veins leave the midvein at c. 60°, forking once close to the midvein, diverging slightly and arching to meet the margin at a high angle.

Holotype

AMF113400. Australian Museum, Sydney.

Type Locality

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures.

Other Material

AMF113401-113405, AMF113437, AMF113441, AMF113450, AMF113467, UNEF13608, all from Coal Mine Quarry, Nymboida.

Name Derivation

trulla - Latin, *basin*, referring to the Type Locality within the Basin Creek Formation.

Discussion

A. nymboidensis Holmes (this paper), *A. menendezii* de la Sota and Archangelsky (1962), *A. hilariensis* Menendez (1957) and *A. rigbyana* Herbst (1977a) differ from *A.*

trullensis by their synangia, which cover all the surface of the pinnule lamina. *A. hillae* (Walkom) Herbst (1977a) and *A. diameson* Holmes (this paper) differ by their smaller sized synangia.

Asterotheca nymboidensis Holmes sp. nov.
Figures 8 A, 9 A-C, 10 A-C.

1975 *Asterotheca hillae* non Walkom, Flint and Gould, Pl.1, figs 1,2.
1975 *Cladophlebis concinna* non (Presl) du Toit, Flint and Gould Pl.1, figs 7,8.
1977 *Asterotheca menendezii* non de la Sota and Archangelsky, Bourke et al. p.19, fig.3.3

Diagnosis

Bipinnate fern with sterile pinnules oblong, apex rounded, with length to breadth ratio of c. 2-2.5:1. Lateral veins straight, once forked close to midvein. Fertile pinnules narrower with length to breadth ratio of 3-3.5:1, bearing seven to eight pairs of quadrisporangiate contiguous synangia c. 0.75-1 mm in diameter, arranged on either side of the midvein and filling all of the lamina space. Sterile and fertile pinnules sometimes on same pinna.

Description

Bipinnate, pinnae opposite to subopposite; attached to the primary rachis at c. 90° proximally and then at a decreasing angle distally, usually straight but sometimes decurving; to 100mm long and 18 mm wide from base to midpoint then decreasing in width towards the acute apex.

Sterile pinnules (Fig. 8A) opposite to sub-opposite; closely spaced but free to the base where the basiscopic margins may be shortly confluent on the rachis; attached at c. 80°; margins parallel or slightly tapering, entire, apex acuminate to obtuse; pinnules straight to slightly falcate; length from 8-14 mm and width from 4-6 mm, smaller towards the apices of the pinnae and frond. The length to width ratio is c. 2-2.5:1. Midvein prominent, slightly decurrent on rachis and then running straight to the pinnule apex. Five to eight pairs of lateral veins are attached at c. 60°, forking close to the midvein, diverging then running almost straight and parallel to meet the margin at c. 45°. Very rarely a lateral vein will fork a second time.

Fertile pinnules narrower than the sterile pinnules (Fig. 9 B,C), with a length to width ratio of 3-3.5:1, broadly decurrent, attached at c. 60°-90°. Seven to eight pairs of synangia are attached to either side of the pinnule midrib and occupy the whole surface of the lamina between the midvein and margin (Fig. 8A; 9A,C). Synangia (Fig. 10A-C) c. 0.75-1 mm in diameter with a square or rosette form of arrangement of four, occasionally three or five, spherical to ovoid sporangia each c. 0.4-0.5 mm in diameter. Sporangial cell walls longitudinally elongate (Fig. 10C).

Holotype

AMF113408. Australian Museum, Sydney.

Type Locality

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures.

Other Material

AMF113406, AMF113409-113413, UNEF13396, UNEF13401, UNEF14122-3. All from Reserve Quarry.

Name derivation

nymboidensis - from Nymboida.

Discussion

Asterotheca nymboidensis was one of the larger and more common ferns in the Nymboida Flora. The form of the living plant is not known.

The Nymboida material here described as *A. nymboidensis* was included with *Scolecopteris australis* Shirley (1898) (= *Cladophlebis australis* Walkom 1917) in *Asterotheca menendezii* de la Sota and Archangelsky (1962) by Herbst (1977a). *A. menendezii* differs from *A. nymboidensis* by the narrower, longer, more widely spaced fertile pinnules and by the greater number of synangia per pinnule. The number of synangia per pinnule in *A. nymboidensis* is c. 8-16; for *A. menendezii,* c. 18-24. The length to width ratio of pinnules of *A. nymboidensis* is c. 3:1 and for *A. menendezii* c. 4-5:1.

A. nymboidensis differs from *A. trullensis* by its opposite to subopposite attachment of pinnae and pinnules, by the lesser length to width ratio of the sterile pinnules and by the contiguous synangia which fill the whole of the pinnule lamina.

A. hillae (Walkom) Herbst (1977a) and *A. denmeadii* Walkom (Herbst 1977a), which are regarded as synonyms by Rigby (1977), differ from *A. nymboidensis* by the smaller synangia which occupy only a portion of the pinnule lamina. *A. rigbyana* Herbst (1977a) and *A. hillae* differ by the unforked lateral veins. *Asterotheca* sp. from the Sydney Basin (Herbst 1977a) differs by its trisporangiate synangia. *A. truempyi* Frenguelli (1943) from Argentina differs by the pinnules bearing less synangia and by the unforked lateral venation. *A. hilariensis* Menendez (1957) differs by its venation which was shown as once forked and strongly recurving by Menendez (1957) or unforked by Herbst (1977a).

Asterotheca chevronervia Holmes sp. nov.
Figures 11 A, 12 A-D.

Diagnosis

Large bi-(tri ?) pinnate frond; pinnules pecopteroid, closely spaced to overlapping; length to width ratio 2.5-3 : 1. Lateral veins opposite, straight, unforked, each pair forming a shallow V shape. Fertile pinnules similar in shape to the sterile pinnules; eight to nine pairs of synangia fill the whole of the lamina surface between the midrib and pinnule margin.

Description

Complete fronds not known. The type specimen (Fig. 11A) shows numerous pinnae, some of which are attached to smooth rhachises to 10 mm wide. Such fronds, when complete would have measured at least 2 m in length. Also on this specimen there are portions of axes to 40 mm in width. Perhaps these are the primary rachises of a tripinnate fern with fronds which may have exceeded 3 m long. Pinnae sub-opposite to alternate, attached at 50°-70°, closely spaced to overlapping; to 120 mm long and 10 mm wide; tapering distally. Pinnules oblong with rounded apex, entire, 1-2 mm wide, 3-6 mm long. Separated to the base but closely spaced to over-lapping; attached to the coarsely, longitudinally ribbed pinnae at 60°-80°; midvein straight, continuing almost to pinnnule apex. Eight to ten opposite pairs of unforked lateral veins are attached at c. 45°-60° and run straight to margin. Fertile pinnules similar in shape to sterile with c. eight pairs of synangia on either side of the midvein fill all the space between the midvein and lamina margin. Details of synangia are poorly preserved.

Holotype

AMF113414, paratypes AMF113415-113416, AMF113456-113458, AMF113462-113463. Australian Museum, Sydney.

Type locality

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures.

Name derivation

chevronervia - referring to the chevron-like arrangement of the lateral veins.

Discussion

A.chevronervia is a rare fern having been collected from a single horizon only, where it was locally abundant. It is distinguished from the other Nymboida ferns by the unforked lateral venation. Sterile fronds closely comparable to *A. chevronervia* have been figured from the Molteno Formation of South Africa by Anderson and Anderson (1983, pl. 8) as *Cladophlebis* sp. "D". *A. hillae* (Walkom) Herbst (Herbst 1977a) has somewhat similar venation to *A. chevronervia* but differs by the smaller synangia which occupy the outer portion only of the pinnule lamina. *A. rigbyana* Herbst (1977a) is similar to *A. chevronervia* but differs by the greater length to width ratio of the pinnules which are shorter and more widely spaced. *A. truempyi* Frenguelli from Argentina has pinnules with chevron-like venation similar to *A. chevronervia*. However the line illustration of a fertile specimen by Herbst (1977a, pl.1, fig. 3) shows only six or seven synangia on each pinnule. The photographed specimens of *A. truempyi* (Herbst 1977a, pl.3, figs 30, 31, 37) are not well enough preserved to allow comparisons.

Asterotheca diameson Holmes sp. nov.
Figure 14 A

Diagnosis

Tripinnate frond, pinnae opposite. Pinnules small, length to width ratio of c. 1.5:1; bearing nine to ten separated tetrasporangiate synangia each c. 0.5 mm in diameter.

Description

Portion of a tripinnate frond probably exceeding 200 mm in length. Secondary rachis tapering from 2.5 mm to 2 mm in the 90 mm preserved. Pinnae opposite, attached at 75°-85° to rachis, 6-7 mm apart, overlapping, linear, 9 mm wide, length may exceed 60 mm. Pinnules closely spaced, alternate, attached to pinna rachis at 70°-85° by whole base, 3-4 mm long and 2.5 mm wide, margins parallel, apex rounded. Length to width ratio of 1.2-1.6: 1. Nine to ten tetrasporangiate synangia per pinnule, each c. 0.5 mm in diameter, well separated, aligned around pinnule midway between the midvein and the pinnule margin.

Holotype

AMF113420 and counterpart AMF113421. Australian Museum, Sydney.

Type Locality

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures.

Name Derivation

diameson - Greek - *midway*; referring to the position of the line of synangia between the midvein and pinnule margin.

Discussion

This is a rare fern, being known only from a single specimen and its counterpart. It is unusual in being preserved in a rare reddish-purple siltstone horizon which is normally unfossiliferous.

On the edge of the type specimen there is a fragment of a second pinna which is aligned with the main illustrated pinna in a manner that strongly suggests that this was a tripinnate fern.

A. diameson differs from *A. trullensis* Holmes and *A. nymboidensis* Holmes by the shorter, straight pinnules and by the fewer and smaller synangia. *A. rigbyana* Herbst (1977a) is similar to *A. diameson* in pinnule size and shape but differs by the larger synangia which cover the whole of the pinnule surface. *A. truempyi* Frenguelli (1943) differs by its fewer and contiguous synangia.

In synangial form and arrangement, the following four fertile fern fragments are distinct and have close affinities with *Asterotheca*. However, due to the small fragments available, they are illustrated and described briefly, without assigning them to species.

Asterotheca sp. A
Figure 13 A.

Description

A fertile pinna fragment showing portions of four pinnules with decurrent basiscopic bases. The pinnules vary in length and width from 13 x 5 mm to 12 x 6 mm and are probably attached at a high angle to the rachis. The tetrasporangiate synangia are closely spaced but not contiguous, c. 0.2-0.3 mm in diameter, aligned parallel to the margin and midway between margin and midvein.

Material

AMF113417, Coal Mine Quarry, Nymboida.

Discussion

The fertile pinnules on this specimen differ from all known Gondwana *Asterotheca* species.

Asterotheca sp. B
Figure 13 B.

1977b *Reinitsia whitehousei* Herbst in part, pl.1, fig.7; pl.2, fig.21, only.

Description

A portion of a fertile bipinnate frond with widely separated pinnae. The pinnae are all incomplete. The largest pinna fragment shows five pairs of alternate pinnules, with either decurrent or contracted basiscopic bases. The pinnules are broad-linear, entire, tapering slightly in the distal two thirds to a rounded apex; length c. 10 mm, width c. 4 mm; midvein decurrent, lateral veins perhaps once forking. From 26 to 34 poorly preserved synangia 0.5-0.75 mm in diameter form a single file around and close to the pinnule margin.

Material

QMF42305, on composite slab formerly registered UQF64174. Nymboida Colliery.

Discussion

This frond fragment was included by Herbst (1977b) in his *Reinitsia whitehousei* (see discussion below under *Herbstopteris colliveri*).

Asterotheca sp. B does not belong in *Herbstopteris*. *Asterotheca falcata* de la Sota and Archangelsky (1962) and *A. menendezii* de la Sota and Archangelsky (1962) both have numerous synangia but differ from *Asterotheca* sp. B in synangial details and pinnule shape.

Asterotheca sp. C
Figure 13 C.

Description

Pinna fragments with alternate, broad, overlapping pinnules, c. 6 mm long and 3 mm wide, with decurrent midvein and c. 10 pairs of lateral veins that appear to fork close to the midvein. Some of the pinnules have a few poorly preserved synangia c. 0.5-0.8 mm in diameter spaced irregularly around the lamina margin.

Material

AMF113418. Coal Mine Quarry, Nymboida.

Discussion

These specimens may possibly be partially fertile or immature fertile pinnae of *A. trullensis*.

Asterotheca sp. D
Figure 13 D.

Description

Fertile pinna fragment with six pairs of oblong pinnules 8-9 mm long and 4-5 mm wide, with about 20 tetrasporous synangia forming a contiguous line around pinnule midway between the strong midvein and the pinnule margin.

Material

AMF113419. Coal Mine Quarry, Nymboida.

Discussion

This form is closest to *A. trullensis* but differs by the contiguous arrangement and greater number of synangia on the pinnules.

Genus *Herbstopteris* Holmes gen. nov.

Diagnosis

Medium sized cladophleboid fern with bipinnate fronds radiating from a rhizotomous base. Primary and pinna rachises prominently longitudinally ridged. Frond broad elliptical with pinnae bearing falcate confluent pinnules which conjoin distally and apically to become lobate to entire. Proximal pinnules with decurrent midvein and once forked lateral veins. As pinnules coalesce, venation changes to a single vein entering each lobe, arching and forking once. Fertile pinnules with a single row of tetrasporangiate synangia on either side of pinnule midvein, with a basal synangium on decurrent portion of the pinnule lamina. Distally and apically as pinnules coalesce, the line of synangia follows parallel to the lobate or entire pinna margin.

Discussion

The genus *Herbstopteris* is erected for certain fertile fronds from Denmark Hill in the Late Triassic Ipswich Coal Measures of Queensland that have been placed previously in *Thinnfeldia, Asterotheca* or *Reinitsea*. Walkom (1917, pl.1, fig.3; pl.3, fig.3) described and illustrated the terminal portions of two pinnate fronds which he believed were the fertile leaves of *Thinnfeldia* (= *Dicroidium*). Based on abundant material from the Molteno Formation of South Africa Thomas (1933) demonstrated that *Dicroidium* was a seed-bearing pteridosperm. Townrow (1957) argued that Walkom's fertile specimens were ferns which he placed in *Asterotheca fuchsii* (Zeiller) Kurtz (Kurtz 1921). I have examined

the material in the Natural History Museum (London) which were described in Townrow's paper. It is a mixed collection of fern fragments from the Ipswich Coal Measures of Queensland and one from Brookvale in the Sydney Basin. Two specimens (NHMV4208 and V24467) are indeterminate *Asterotheca* spp., one (NHMV5950) is too poorly preserved to make comparisons; the Brookvale specimen (NHMV32112) is totally sterile and cannot be satisfactorily identified. Only two specimens (NHMV24632a and b), an apical portion of a fertile frond and its counterpart are similar to the material described and figured by Walkom (1917) as fertile *Thinnfeldia*. They are quite distinct from *A. fuschii*. These two specimens I include below in the new genus *Herbstopteris*. In a revision of some eastern Australian and Argentinean ferns Herbst (1977a) transferred Walkom's specimens to a new species in the genus *Reinitsia* as *R. colliveri* Herbst. The genus *Reinitsia* was erected by Walkom (1932) for a fragment of a fern with long linear lobate pinnae with the proximal portion of the pinnae fertile. Tetrasporangiate synangia were arranged in a single file parallel to the lobate pinna margin. On the distal sterile portions of the pinnae the well-preserved lateral venation comprised single veins leaving the pinna rachis at an acute angle then branching irregularly two or three times into each lobe. This unusual form of venation is quite unlike Walkom's (1917) 'fertile *Thinnfeldia*' and others that were included by Herbst (1977a) in *Reinitsia*. I am not aware of any other Gondwana Triassic fern with this irregular venation architecture although it is similar to that in the simple leaves of the pteridosperm *Dejerseyia lobata* (Jones and deJersey 1947; Anderson and Anderson 1983). Based on this difference in venation I now place *Reinitsea colliveri* in the new genus *Herbstopteris*.

In the genus *Asterotheca* the fronds are bipinnate with the pinnules separated to the base. The lines of synangia are parallel from the base until they curve and join at the pinnules' rounded apices.'*Herbstopteris* has similar, usually four-sporangiate synangia but differs from'*Asterotheca* by the pinnules being basally decurrent on the pinna rachis and by the line of synangia following around the base of the decurrent portion to form a U shape between adjacent pinnules. Distally and apically the pinnules coalesce to form lobed or entire pinnae while the line of synangia follows parallel to the lobed or entire margin, characters not present in *Asterotheca*.

Additional and more complete material from Nymboida supports the erection of the new genus *Herbstopteris*.

Name derivation

Herbst - in recognition of the eminent Argentinean palaeobotanist Dr Raphael Herbst who has carried out extensive research on Gondwana ferns over the last forty years.

pteris – Greek, fern.

Herbstopteris colliveri (Herbst) Holmes comb. nov.
Figures 15 A, B, 16 A-C, 17 A-D.

1917 *Thinnfeldia feistmantelii* non Johnston, Walkom in part, p.17 text fig.3, pl.1, fig.3 only.
1917 *Thinnfeldia lancifolia* non Morris, Walkom in part, p.21, pl.3, fig.3 only.
1957 *Asterotheca fuchsii* non (Zeiller) Kurtz, Townrow, p.22, pl.2, fig.A only.
1965 *Asterotheca* (*Pecopteris*) *fuchsii* non (Zeiller) Kurtz, Hill et al, pl. T3, fig.6.
1977b *Reinitsia colliveri* Herbst, p.24, figs 1-6, 16-20.
1977b *Reinitsia whitehousei* Herbst, figs 8-10, 22-25 only.

Description

Small to medium sized fern with up to nine broad elliptic fronds of various sizes, radiating from an elongated rhizome c. 25 mm wide. Complete fronds estimated to range from 150 mm to 300 mm long. Portions of pinnae in the lower to mid portion of the frond and proximal to the main rachis bear well-developed pinnules which are conjoined by a narrow wing along the pinna rachis. Towards the distal portions of the pinnae and the apical part of the frond the pinnules coalesce to form lobate to entire pinnae. Proximal sterile pinnules *Cladophlebis*-like, decurrent, oblong to slightly falcate, margins entire, apex acuminate to obtuse, 4-8 mm long and 2-3 mm wide. Midvein straight, lateral veins well-spaced, forking once midway to the margin. As the pinnules coalesce distally and apically the venation changes to a single arching once-forked vein into each marginal lobe. On fertile portions of fronds, the mostly 4-sporangiate synangia, 0.5-1 mm in diameter, form a single row close to and parallel to the pinnule margin. Usually one or more synangia are attached around the decurrent basiscopic wing to form an open U-shape with the synangia on the adjacent pinnule; eight to twelve synangia per pinnule. As the pinnae taper distally and apically, the number of synangia on each pinnule decreases until they form an undulate or straight single file close and parallel with the margin of the coalesced pinnules.

Material

AMF113425-113431, Coal Mine Quarry, Nymboida. QMF42303, QMF42304, QMF42306. Nymboida Colliery, Nymboida.

Discussion

The Type specimen for *H. colliveri* is Geological Survey of Queensland Fossil Number 730 as selected by Herbst (19977b) for his *Reinitsea colliveri*.

The Nymboida specimen (Fig. 15A,B) with both sterile and fertile fronds radiating from a common base is very important in demonstrating the habit of growth of this fern. Figures 15B and 16C show the change in form of a single frond from bipinnate basally and close to the main rachis then lobed to simply pinnate distally on the pinnae and apically on the frond. Other Nymboida specimens with only the apical portion preserved (Figs 16A,B and 17A-D) are closely similar to the Ipswich material of *Herbstopteris colliveri*.

Based on material from the Nymboida Colliery, Herbst (1977b) erected a new species, *Reinitsia whitehousei*. His type material comprised a single slab (formerly catalogued as University of Queensland F64174) bearing a portion of a bipinnate-pinnate fertile frond associated with fragments of pinnae with elongated fertile pinnules bearing up to 34 synangia around each pinnule. Herbst considered all the material on this slab represented the range of variation within a single taxon. I have examined Herbst's specimens which are now in the Queensland Museum. The bipinnate-pinnate frond and the elongate fertile pinnae are two separate entities. One of the latter pinnae (now catalogued QMF42305) is figured above as *Asterotheca* sp. B (Fig. 13B). The frond (QMF42306) and other fragmentary pinnae in Herbst's collection (QMF42303-4) all fit comfortably within the range of variation of *Herbstopteris colliveri* and thus *Reinitsea whitehousei* is regarded as a later synonym of that species.

Herbstopteris sp. A
Figure 14 C.

Description

Two isolated parallel fertile pinna fragments, pinnules well-separated, to 7 mm long and 3.5 mm wide, bases strongly decurrent, bearing 14-20 synangia 0.25-0.5 mm in

diameter, irregularly spaced parallel to the pinnule margin, the basiscopic synangia following around the decurrent base.

Material

AMF113423-113424. Coal Mine Quarry, Nymboida.

Discussion

This specimen differs from *Herbstopteris colliveri* by the broader, more separated pinnules and by the more numerous and smaller synangia, but as it is the only specimen available, it has not been formally named.

Order Osmundales
Family Osmundaceae R. Brown 1810.
Genus *Todites* Seward 1900.
Type species *Todites williamsonii* (Brongn.) Seward 1900.

The genus *Todites* was widespread in the Triassic and became cosmopolitan during the Jurassic and Cretaceous (Boureau 1970). It is based on fertile material where the *Osmunda*-like sporangia are attached to the pinnules to form an irregular mass, often covering the whole underside of the lamina. Leaves of similar form but known only in the sterile state are normally placed in the *Cladophlebis* genus. *Todites* have been recorded in the Triassic of Gondwana by Walkom (1928), Burges (1935), Holmes (1982), Anderson and Anderson (1983), Retallack (1983) and Herbst (1989).

Todites parvum Holmes sp. nov.
Figures 18 A- E.

?1898, *Triphyllopteris botryoides* Shirley, p.20, pl.7, fig.1, middle and right hand specimens only.
?1917, *Coniopteris delicatula* Walkom, p.6, text fig.3, pl.4, fig.2

Diagnosis

A small bipinnate fertile frond; pinnules sub-opposite to alternate, triangular to elongated, margins lobed, broadly falcate, apex obtuse to acute. Sporangia circular, closely spaced, irregularly arranged on the whole undersurface of the pinnules.

Description

This is a rare fern element at Nymboida with only four specimens in the collections. Sterile fronds have not been recognised. The holotype (fig.18 A,B) is an apical portion of a bipinnate frond with opposite pinnae bearing closely spaced, alternate to sub-opposite pinnules. Pinnules in the proximal half of the lower preserved pinnae are triangular or broadly falcate, c. 2 mm wide and to 2.5 mm long, contracting to an obtuse or acute apex. Pinnules decrease in size distally on the pinnae and towards the apical portion of the frond. The pattern of venation can not be seen. About 15-20 closely spaced sporangia, each c. 0.25 mm in diameter cover the whole under surface of the pinnules. On other specimens (figs 18 C-E) the lamina tissue of the pinnules has not been preserved and the specimens show masses of sporangia at the position of the pinnules on either side of the pinna rachis.

Holotype

AMF113432 and counterpart AMF113433. Australian Museum, Sydney.

Type Locality

Coal Mine Quarry, Nymboida, Basin Creek Formation, Nymboida Coal Measures.

Other material

AMF113434-113436. Coal Mine Quarry, Nymboida.

Name Derivation

parvum - Latin - *small*, referring to the size of the pinnules.

Discussion

As most *Todites* spp. have dimorphic fronds it is difficult to make comparisons between taxa when only sterile or fertile fronds are present. *Todites parvum* is known only from fertile fronds. It is possible that the sterile fronds are also present in the collections but their affiliation with the fertile fronds is not, at present, recognised.

Fertile and sterile fronds from the Esk Beds were assigned by Walkom (1928) and Hill et al. (1965) to the Northern Hemisphere *Todites williamsoni*. The Esk forms differ from *T. parvum* by their greater size and by their orbicular shaped pinnules. *Todites narrabeenensis* Burges (1935) and *Todites* sp. Herbst (1989) have fertile pinnules of similar size to *T. parvum*. However *T. narrabeenensis* differs by its pinnatisect pinnae with crenulate margins; *Todites* sp. differs by its circular pinnules and more numerous sporangia. Of the figured but undescribed *Todites* species of Anderson and Anderson (1983), *Todites* sp. A and *Todites* sp. B have larger, elongate, lobed pinnules and *Todites* sp. C has pinnules similar in shape to *T. parvum* but differs by the much larger size and more numerous tiny sporangia. *T. pattinsoniorum* Holmes (1982), *T. maoricus* Retallack (1983) and *T. baldonii* Herbst (1989) are much larger in size and are known from both fertile and sterile material.

Shirley (1898) described some fragments of fertile fronds together with a sterile pinna from Shorncliffe in the Ipswich Series of south-eastern Queensland as *Triphyllopteris botryoides*. The same specimens, together with more complete associated sterile fronds were assigned by Walkom (1917) to *Coniopteris delicatula* (Shirley) Walkom. Rigby (1977) expressed doubts that these leaves belong in *Coniopteris*. While the fertile fragments are described as being parts of a lobate frond, the individual pinnules are closely similar in size and sporangial arrangement to *T. parvum*. Neither sterile fronds similar to *Coniopteris delicatula* nor other sterile fronds that could be affiliated definitely with *T. parvum* are known from Nymboida.

Genus *Osmundopsis* Harris 1931
Type species *Osmundopsis sturi* (Raciborski) Harris 1931.

Osmundopsis scalaris Holmes sp. nov.
Figures 19A,B; 20A-C; 21A.

Diagnosis

Medium sized fern with bipinnate fronds radiating from a rhizomotous base; sterile pinnules cladophleboid, lateral veins well-spaced, once forked. Fertile pinnules with much reduced lamina, with c. 15-20 spheroidal or ovoid sporangia c. 1 mm in diameter, closely spaced on either side of the midvein. Fertile and sterile pinnae sometimes occurring on same frond.

Description

The holotype (Fig. 19A) is a beautiful and unique specimen. At least seven fronds, including two that are partially fertile, radiate from a common base to show the form of

growth. Another specimen (AMF113447) shows fronds attached to a rhizome. The two fronds on the holotype which bear sterile pinnae near the base and apex with fertile pinnae in the middle portion of the primary rachis, are important in providing the key to allow affiliation of isolated fragments where only fertile or sterile material is preserved.

Bipinnate fronds with opposite to sub-opposite, well-spaced pinnae are attached at c. 70°-80° to a slender primary axis to c. 50 cm in length. Sterile pinnae to 50 mm long and 20 mm wide, broad-linear, decreasing in width distally. Sterile pinnules (Fig. 19B, Fig. 20B, Fig. 21A) sub-opposite to alternate, attached at 70°-90°, adjacent to well-spaced, free to the base which may be slightly contracted or decurrent; 9-12 mm long and 3-4 mm wide, with a length to width ratio of 3:1. Lateral venation at c. 45° to midvein, well-spaced, once-forked. Fertile pinnae to c. 40 mm long and c. 10 mm wide. Fertile pinnules (Figs 19A, 20A, C) attached opposite to sub-opposite at 80°-90°; 6-8mm long, with much reduced lamina. Fifteen to twenty sporangia, spheroidal to ovoid, each c. 1 mm in diameter are closely spaced on either side of the midvein (Fig. 20C). Cell structure and annulus not preserved.

Holotype

AMF113468. Isotypes - fragments removed from the Holotype slab. AMF113438-9, AMF113444-6, AMF113452-55, AMF113469-75. Australian Museum, Sydney.

Type Locality

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures.

Other Material

AMF113443, AMF113447. Coal Mine Quarry, Nymboida.

Name Derivation

scalaris - Latin - *ladder-like*, referring to the appearance and arrangement of the fertile pinnules.

Discussion

Andrews in Boureau (1970) queried the reasons given by Harris (1961) for the erection of the genus *Osmundopsis*. Andrews considered that the features of *Osmundopsis* coincided with those of the extant genus *Osmunda*. I consider the placing into a separate genus of fragmentary fossil material in which the finer details of structure may be missing, is preferable to assuming that the fossil is congeneric with extant material.

In various features of gross morphology *Osmundopsis scalaris* resembles some extant osmundaceous ferns with dimorphic fronds on which the fertile pinnae have greatly reduced laminae. However, the lack of spores and the absence of finer details of the sporangia does not allow for closer comparison.

Osmundopsis scalaris differs from *O. sturi* (Raciborski) Harris (1931, 1961) by the fewer and larger sporangia and from *O. plectrophora* Harris (1931) which is tripinnate in the fertile state.

From the Upper Triassic Lashley Formation of Antarctica, Taylor et al. (1990) illustrated a fragment of a dimorphic bipinnatifid frond which bore on the same primary rachis both sterile pinnae with deeply dissected segments with *Cladophlebis*-type dichotomous venation and short non-laminate fertile pinnae with tightly compacted clusters of sporangia along the pinna midvein. The authors drew attention to the similarity of the frond morphology of the fossil to that of the extant fern *Osmunda claytoniana*. The Antarctic material, which was not formally described, has similar sterile pinnae to *Osmundopsis scalaris* but differs by its very short simple fertile pinnae.

Several specimens in the Nymboida collections show sterile fronds radiating from a common base. Some fronds show the primary and secondary rachises strongly grooved while others have smooth rachises. The rachises in life were probably kidney shaped in transverse section as in extant osmundaceous ferns. The appearance of the resulting fossil following compression depends on whether the fossil is a cast or mould of the upper or lower surface of the original plant. The smooth stemmed fossils represent a cast or mould of the upper convex surface - ridged or grooved stems would be casts or moulds of the concave lower surface.

Order Filicales
Family Gleicheniaceae
Genus
Gleichenites Goeppert 1836
Type species *Gleichenites porsildii* Seward 1926

Gleichenites wivenhoensis Herbst (1974)
Figure 14 B.

1974 *Gleichenites wivenhoensis* Herbst p.79, figs 1,2, pl.9, figs 7,8, pl.10,fig.11.

Description

The two parallel pinnae illustrated on Fig. 14B suggest that they were from a bipinnate frond. These incomplete pinnae are 35 mm and 45 mm in length, tapering distally from 7 mm in width. The pinnules, which are separated to the base, are short, broad and falcate, c. 2.5 mm wide and 4 mm long, acuminate to obtuse, decreasing in size towards the pinna apex. They are attached to the pinna rachis at c. 45°. Basiscopic margin more convex than acroscopic margin; venation not preserved. Proximal fertile pinnules bear five to seven tetrasporangiate synangia which are aligned on either side of the pinnule midvein and occupy most of the lamina. The smaller distal pinnules bear less synangia.

Material

AMF113422, AMF11424. Reserve Quarry, Nymboida.

Discussion

In outline, sterile fragments of *G. wivenhoensis* could be confused with portions of *Dicroidium* leaves.

G. wivenhoensis differs from other *Gleichenites* species by its soral characters (Herbst 1972, 1974, 1996; Herbst et al. 1998). *Eboracia herbstii* Rigby (in Playford et al. 1982), from the Middle Triassic Moolayember Formation of Queensland has long linear pinnae with fertile pinnules similar in size but more rounded than *G. wivenhoensis*. As the base of the pinnae of the Nymboida material is not preserved, comparisons cannot be made with *Eboracia* spp. in which the diagnostic character is a greatly enlarged basiscopic pinnule. Phipps et al. (2000) have described silicified gleicheniaceous sori as *Gleichenipteris antarcticus*. The poor preservation of the sori of *Gleichenites wivenhoensis* does not allow for comparison with *G. antarcticus*.

Family Dipteridaceae
Genus *Dictyophyllum* Lindley and Hutton 1834
Type species *Dictyophyllum rugosum* Lindley and Hutton 1834

Dictyophyllum davidii Walkom 1917, p.10.
Figures 22A-E. 23A-C.

1917 *Dictyophyllum Davidi* Walkom, p.10, pl.3, fig.2.
1924 *Dictyophyllum rugosum* L&H; Walkom, p.82, pl.21, fig.1.
1965 *Dictyophyllum davidi* Walkom; Hill et al. p.T6, pl.3, fig.1.
1975 *Dictyophyllum davidii* Walkom; Flint and Gould, p.71; pl.1 fig.3.
1982 *Dictyophyllum davidii* Walkom; Webb, p.85, figs. 6A, 7, 8.\

Description

The Nymboida material, while containing specimens that agree well with the type specimen (UQF165) of Walkom (1917) from the Esk Formation of south-eastern Queensland, also includes a wider range of variation which is illustrated in Figures 22 and 23. Fronds are borne on a long slender primary rachis which may exceed 150 mm in length (Fig. 22A) and have a typical dipteridacean branching pattern in which the main rachis bifurcates into two arms although both arms are rarely preserved intact. Each arm bears five to eight pinnae attached in a pseudo-palmate arrangement. The pinnae are very shortly petiolate, lanceolate and of varying size and lobation, to 70 mm long and to 25 mm wide. The number of lobes and the depth of dissection is variable. Venation consists of a strong median vein with well-spaced secondary veins, one to each lobe, passing straight to the margin at c. 60° (Fig. 22E). Tertiary venation arises at high angles from the primary and secondary veins to form a fine network of square and polygonal meshes throughout the lamina. Fertile pinnae have groups of sori adjacent to the midvein and in the areoles formed by the tertiary veins (Fig. 23C). The sori contain irregular groups of c. 25 or more rounded sporangia each c. 1.5-2 mm in diameter. Details of the annulus are not clear.

Material

AMF113374-113381, AMF113450, AMF113459, AMF113460, UNEF13416. Coal Mine Quarry.

Discussion

Dictyophyllum davidii is the earliest reported member of the genus which had numerous species and a world-wide distribution in the Late Triassic and Jurassic (Boureau 1970; Herbst 1992). The Australian occurrences of *Dictyophyllum davidii*, which are restricted to the Anisian-Ladinian Nymboida Coal Measures and the Toogoolawah Group of the Esk Trough of Queensland, have been discussed in detail by Herbst (1975, 1979) and Webb (1982). *D. davidii* differs from *D. bremerense* and *D. shirleyi* from the late Triassic Ipswich Coal Measures by its generally smaller size and in the spacing and shape of the lateral lobes on the pinnae (Walkom 1917; Webb 1982). *D. tenuiserratum* and *D. chihuiuensis* from the Middle Triassic of Argentina (Herbst 1993) both differ from *D. davidii* by the frond lamina being deeply dissected into elongate lobes with serrate or denticulate margins. *D. ellenbergii* Greber in Fabre and Greber (1960) from the Late Triassic Molteno Formation of Lesotho and *D. tenuifolium* (Stipanicic and Menendez 1949; Bonetti and Herbst 1964; Herbst et al. 1998) from the Late Triassic of Argentina and Chile are somewhat similar in gross morphology to *D. davidii* but because of their geographical and time separation I consider they should be regarded as separate entities.

Genus *Hausmannia* Dunker 1846
Type species *H. dichotoma* Dunker 1846

Hausmannia reticulata Holmes sp. nov.
Figures 3C-E.

Diagnosis

Lamina sub-orbicular to reniform; margin entire; primary veins radiating from lamina base, forking and joining two to three times to form elongate areoles.

Description

The holotype (Figs. 3C,D) is reniform, 25 mm long, 17 mm wide, with rounded lobes symmetrical about the base. Seven veins radiate from the base, forking and conjoining twice to form two transverse rows of broad elongate areoles. The paratype (Fig.3E) is 16 mm wide and 14 mm wide as preserved with basal lobes missing. The radiating veins fork and join two or three times to form two or three rows of areoles more elongate than the holotype. No secondary venation is preserved on either of the specimens.

Holotype

AMF113391. Paratype AMF113392. Australian Museum, Sydney.

Type Locality

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures.

Name Derivation

reticulata Latin, *net-like.*

Discussion

This taxon is extremely rare. Two specimens only have been found during thirty five years of collecting.

Despite the lack of preserved secondary veins at right angles to the primary veins, which in other species of *Hausmannia* form a fine network of quadrangular areoles over the whole lamina, the gross morphology of the Nymboida material suggests its inclusion in *Hausmannia* sensu Herbst (1992).

With the exception of *Hausmannia* (*Protorhipis*) sp. cf. *H. (P.) deferrariisii* from the Jurassic of Queensland (Herbst 1979), which has eight primary veins that enter the deeply dissected lamina and branch and rejoin several times to form a network of decreasing sized meshes anastomosing veins, *H. reticulata* is the only other known species with anastomosing primary veins. Leaves referred to *Chiropteris* (Walkom 1925b; Du Toit 1927), *Gingkophytopsis* (Retallack 1980, 1983) and other new genera in studies yet to be published by Herbst in Argentina and Anderson and Anderson in South Africa, have laminae with reticulate but finer venation. The more elongate character of the meshes and the cuneate to digitate outline of the lamina, distinguish those leaves from *H. reticulata.*

Incertae sedis

Nymbofelicia Holmes gen. nov.

Nymbofelicia aggregata Holmes gen. et sp. nov.

Figures 24 A-D, 25 A-C.

Combined Diagnosis

Bipinnate fertile frond with opposite pinnae bearing linear lobed pinnules. Pinnules with straight median vein and well-spaced lateral veins, one to each lobe and once broadly forking. Fertile pinnules bearing circular sori each formed from a loose aggregate of 10-15 spheroidal sporangia centred below the fork of each lateral vein.

Description

The type specimen is a fragment of a bipinnate frond (Fig. 24A) with the preserved portion of a smooth surfaced primary rachis decreasing from 9 mm to 8 mm over a distance of 10 cm - thus suggesting that the complete frond was at least one metre in length. Pinnae opposite, attached 20 mm apart, at 50°-60° to the primary rachis, 20-22 mm wide, length to c. 70 mm. Pinnules closely spaced, slightly decurved or at right angles to the

pinna rachis (Fig. 24B-D), attached by whole or slightly contracted or decurrent base, linear with acuminate apex, 10-15 mm long, 3 mm wide, margin lobate, c. 7-9 lobes on either side of proximal pinnules, midvein fine and straight with one lateral vein to each lobe leaving midvein at c. 45° and once broadly forked (24D, 25A). Fertile pinnules bearing circular sori c. 1-1.5 mm in diameter centred in each lobe below the fork of the lateral vein. Sori composed of a cluster of c. 10-15 spherical sporangia 0.2-0.4 mm in diameter (Figs 24C, 25B, C). No annulus observed.

Holotype

AMF113448, Australian Museum, Sydney.

Type Locality

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures.

Other Material

AMF113476-7, AMF113479-80.

Name Derivation

Nymbofelicia - contrived - for Nymboida fern

aggregata - Latin - *in clusters*; referring to the arrangement of the groups of sporangia.

Discussion

Nymbofelicia aggregata is based on a single fertile fragment and a few sterile fragments. The genus *Chansitheca* was erected for fertile ferns from the Palaeozoic of China (Halle 1927; Boureau 1970) with pinnules bearing rounded sori comprised of from 8-16 sporangia, each with a distinct annulus – a feature not seen on *Nymbofelicia*. *Chansitheca argentina* was described by Herbst (1963) for a fertile fern fragment from the Upper Triassic of Patagonia. The specimen had pecopteroid pinnules bearing irregular ovoid sori composed of 8-12 pedunculate sporangia. An annulus was not apparent. Herbst also listed other differences to *Chansitheca* sensu stricta. *Chansitheca argentina* may be generically similar to *Nymbofelicia* but differs from *N. aggregata* by the broader pinnules and the irregular arrangement of the sori which are composed of fewer sporangia which form elongated ovals along the lateral veins. Illustrated sterile specimens of *Cladophlebis mendozaensis* (Geinitz) Frenguelli (Frenguelli 1947, pl. 11 fig. 7; Retallack et al 1977, fig. 5B; Herbst 1978, pl. 1, fig. 4) and *Cladophlebis johnstonii* Walkom (Hill et al. 1965, pl.T2, figs 4,5; Jain and Delevoryas 1967) have elongate lobed pinnules similar in outline to *Nymbofelicia aggregata* but differ by the lateral veins being twice forked. *Todites maoricus* Retallack (Retallack 1981, fig. 1, fig. 11A; 1983, fig. 3A-C) also has lobed pinnules similar to *N. aggregata* but differs by the twice forking lateral veins and by the contiguous sori covering most of the pinnule surface.

ACKNOWLEDGEMENTS

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Legends for figures

Figure 1.(A-C).
Ogmos adinus. (A) AMF113382, X0.85. (B) AMF113383, group of superimposed leaves, X0.6. (C) AMF113384, X0.5. Scale bar = 1 cm.

Figure 2.(A). *Marantoidea acara.* AMF113387, distal portion of sterile frond. Scale bar = 1 cm.

Figure 3.(A-B). *Marantoidea acara.* Fertile pinnae. (A) AMF113379, X2. (B) AMF113390, X2. (C–E) *Hausmannia recticulata.* (C,D) Holotype, AMF113391. (D) X2), (E) AMF113392, X2. Scale bar = 1 cm.

Figure 4.(A–B). *Rhinipteris walkomii.* (A) Holotype, AMF113393 X2. (B) Paratype, sterile foliage, AMF113394. Scale bar = 1 cm.

Figure 5.(A–C). *Rhinipteris walkomii,* Paratypes (A) AMF113395, base of primary rhachis. (B) AMF113396, fertile pinnae. (C) AMF113397, sterile and fertile pinnae. Scale bar = 1 cm.

Figure 6.(A). *Asterotheca trullensis.* Holotype. Fertle fronds, AMF113400. Scale bar = 1 cm.

Figure 7.(A–C). *Asterotheca trullensis.* (A,B) Fertile pinnae, X2. (A) AMF113400. (B) AMF113451. (C) Sterile frond, AMF113478. Scale bar = 1 cm.

Figure 8.(A). *Asterotheca nymboidensis.* (A) AMF113409. Frond bearing both sterile and fertile pinnules. Scale bar = 1 cm.

Figure 9.(A–C). *Asterotheca nymboidensis.* All X2. (A) AMF113408, Holotype, showing fertile and sterile pinnules on same pinna. (B) AMF113410, fertile pinnae. (C) AMF113411, fertile pinnae on primary rachis. Scale bar = 1 cm.

Figure 10.(A–C). *Asterotheca nymboidensis.* All AMF113412. (A) X15. (B) X30. (C) X60, showing longitudinally striated sporangial walls. Scale bar = 1 mm.

Figure 11.(A). *Asterotheca chevronervia.* Holotype, AMF113414. Scale bar = 1 cm

Figure 12.(A-D). *Asterotheca chevronervia.* (A-C) Portions of the Holotype, AMF113414 (A) X1. (B-C) Pinnae with sterile and fertile pinnules, X2. (D) AMF113415, sterile pinnae showing chevron-like lateral venation on the pinnules. Scale bar = 1 cm.

Figure 13.(A). *Asterotheca* sp A, AMF113417, X2. (B) *Asterotheca* sp.B, QMF42305, X2. (C) *Asterotheca* sp.C, AMF113418, X2. *Asterotheca* sp.D, AMF113419, X2. Scale bar = 1 cm.

Figure 14.(A). *A. Asterotheca diameson.* AMF113420, Holotype, X1.2.
(B) *Gleichenites wivenhoensis.* AMF 113422, X2. (C) *Herbstopteris* sp.A, AMF113423. Scale bar = 1 cm.

Figure 15.(A,B). *Herbstopteris colliveri.* AMF113425. (A) Fronds radiating from stout rhizome or trunk. (B) Apical portion of fertile frond. Scale bar = 1 cm.

Figure 16.(A-C). *Herbstopteris colliveri. (A)* AMF113426, X2. (B) AMF11342, X2. (C) AMF113429, X2. Scale bar = 1 cm. 7

Figure 17.(A-D). *Herbstopteris colliveri.* (A) AMF113430, X2, (B) AMF113431, X2, (C) AMF113427, X10. (D) AMF113428, X10. Scale bar = 1 cm for (A,B), 1 mm for (C,D).

Figure 18.(A-E). *Todites parvum.* (A,B) AMF113432, Holotype. (A) X10. (B) X2. (C) AMF113434, X2. (D) AMF113435, X2. (E) AMF113436, X2. Scale bar = 1 cm for (A, C-E), 1 mm for (B).

Figure 19.(A,B) *Osmundopsis scalaris.* (A) AMF113468, Holotype, fern with dimorphic fertile and sterile fronds. (B) AMF113438, sterile pinna to show venation, X2. Scale bar = 1 cm.

Figure 20.(A-C). *Osmundopsis scalaris.* (A) AMF113468, Holotype, portion of fertile frond. (B) AMF113469, sterile pinna, X2. (C) AMF113443, fertile pinna, X10. Scale bar = 1 cm for (A,B), 1 mm for (C).

Figure 21.(A). *Osmundopsis scalaris.* AMF113447, three sterile fronds radiating from ?common base. Scale bar = 1 cm.

Figure 22.(A-E). *Dictyophyllum davidii.* (A) AMF113394, with long primary rachis. (B) AMF113375. (C) AMF113376. (D) AMF113377. (E) AMF113378, showing tertiary venation, X2. Scale bar = 1 cm.

Figure 23.(A-C). *Dictyophyllum davidii.* (A) AMF113379. (B) AMF113380. (C) AMF113381, fertile frond, X2. Scale bar = 1 cm.

Figure 24.(A-D). *Nymbofelicia aggregata.* (A-C) AMF113448, Holotype. (A) X1. (B) X2.5. (C) X10. (D) AMF113476, sterile pinna, X1. Scale bar = 1 cm for (A,B and D), 1 mm for (C).

Figure 25.(A-C). *Nymbofelicia aggregata.* AMF113448, Holotype. (A) pinna showing once forked venation, X20. (B) fertile pinna, X20. (C) fertile pinna, X40. Scale bar = 1 mm.

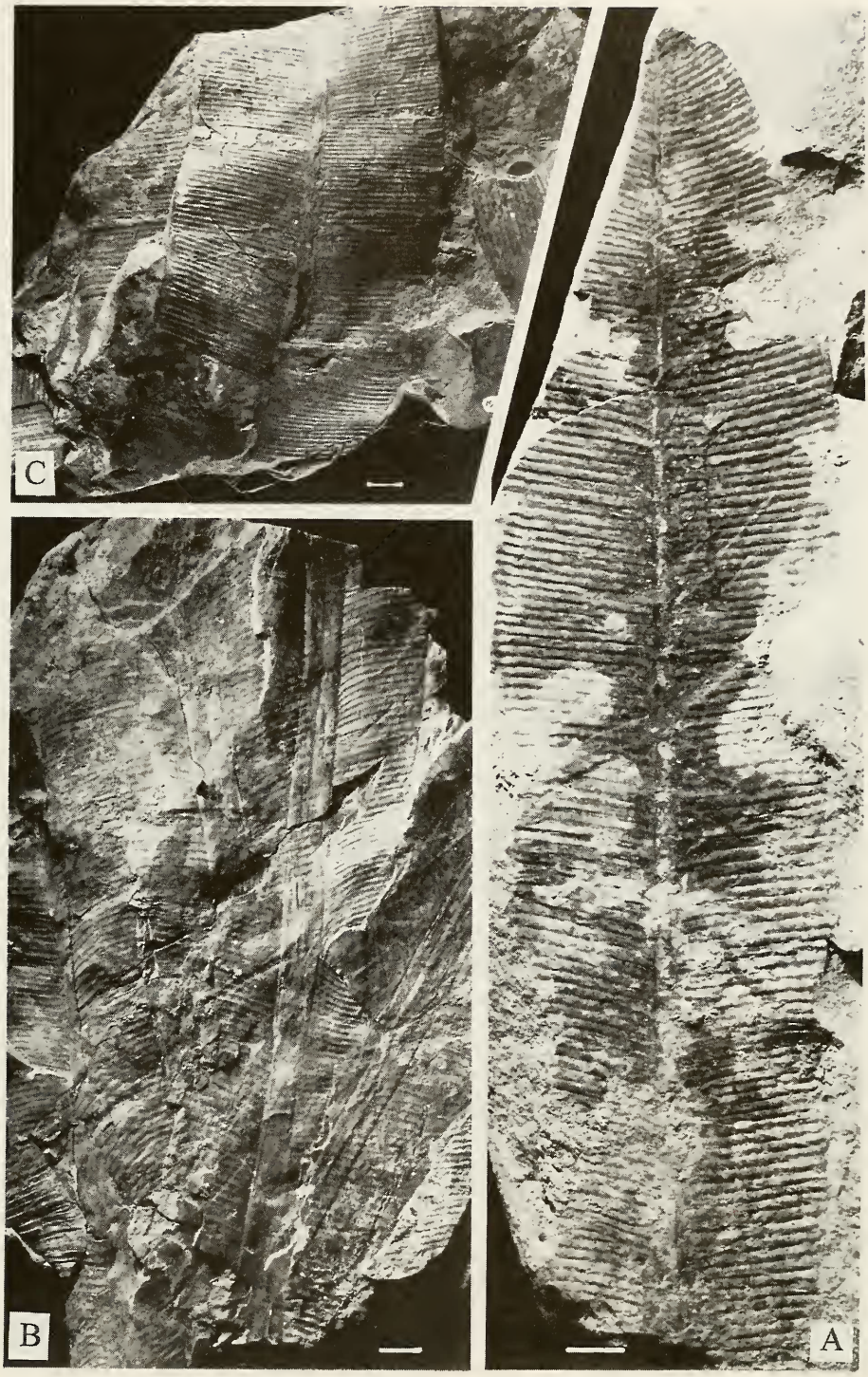

FIGURE 1

FIGURE 2

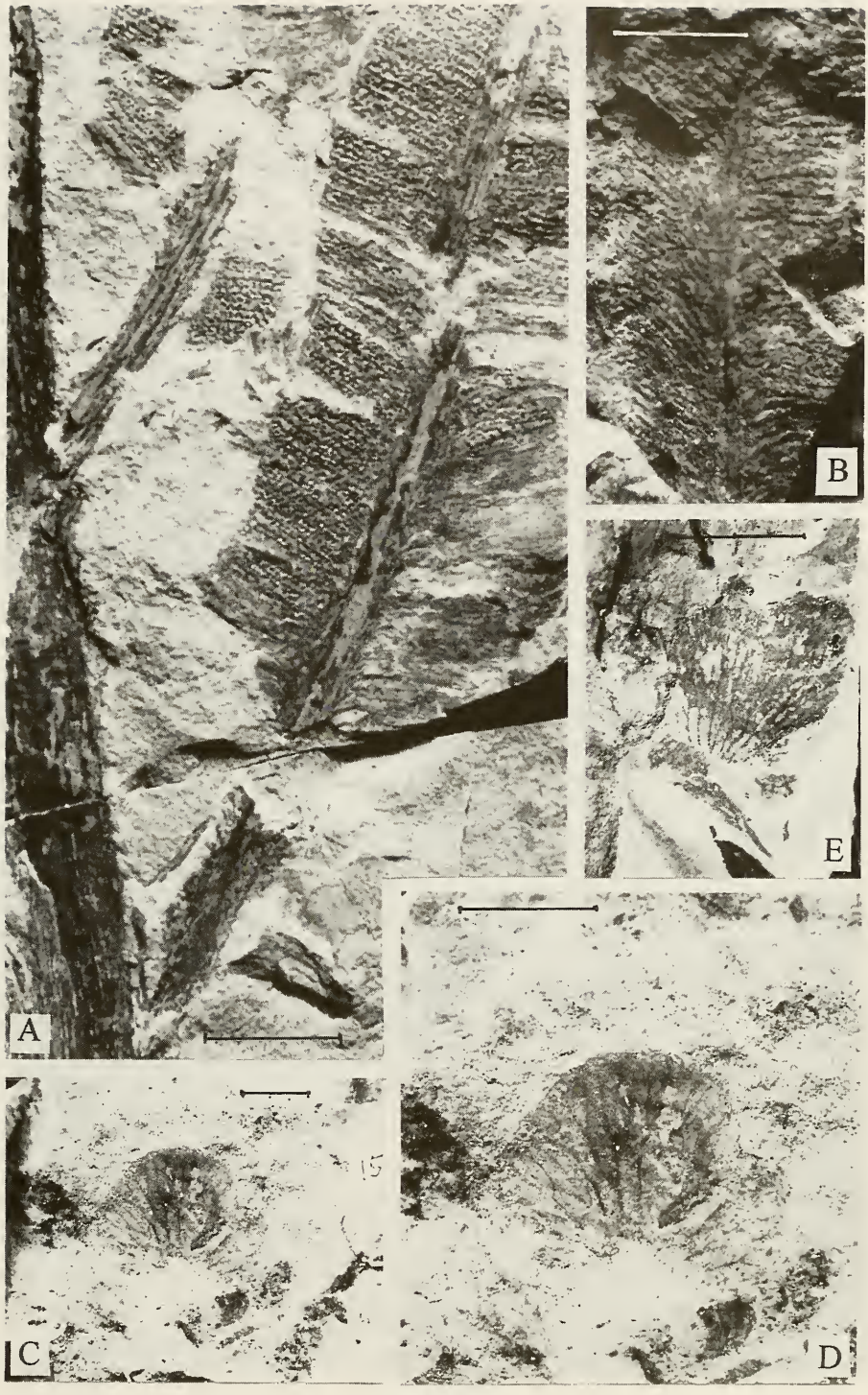

FIGURE 3

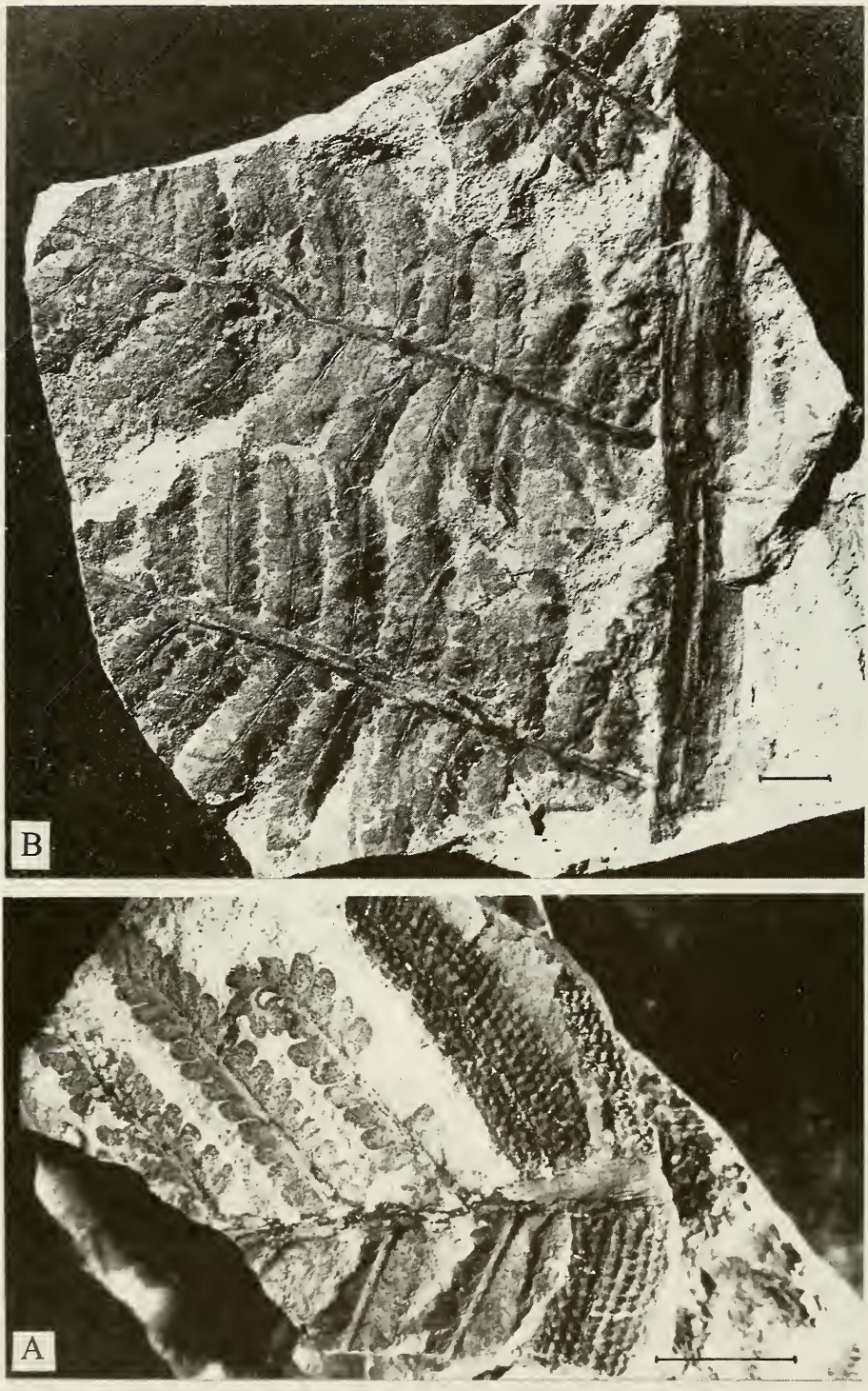

FIGURE 4

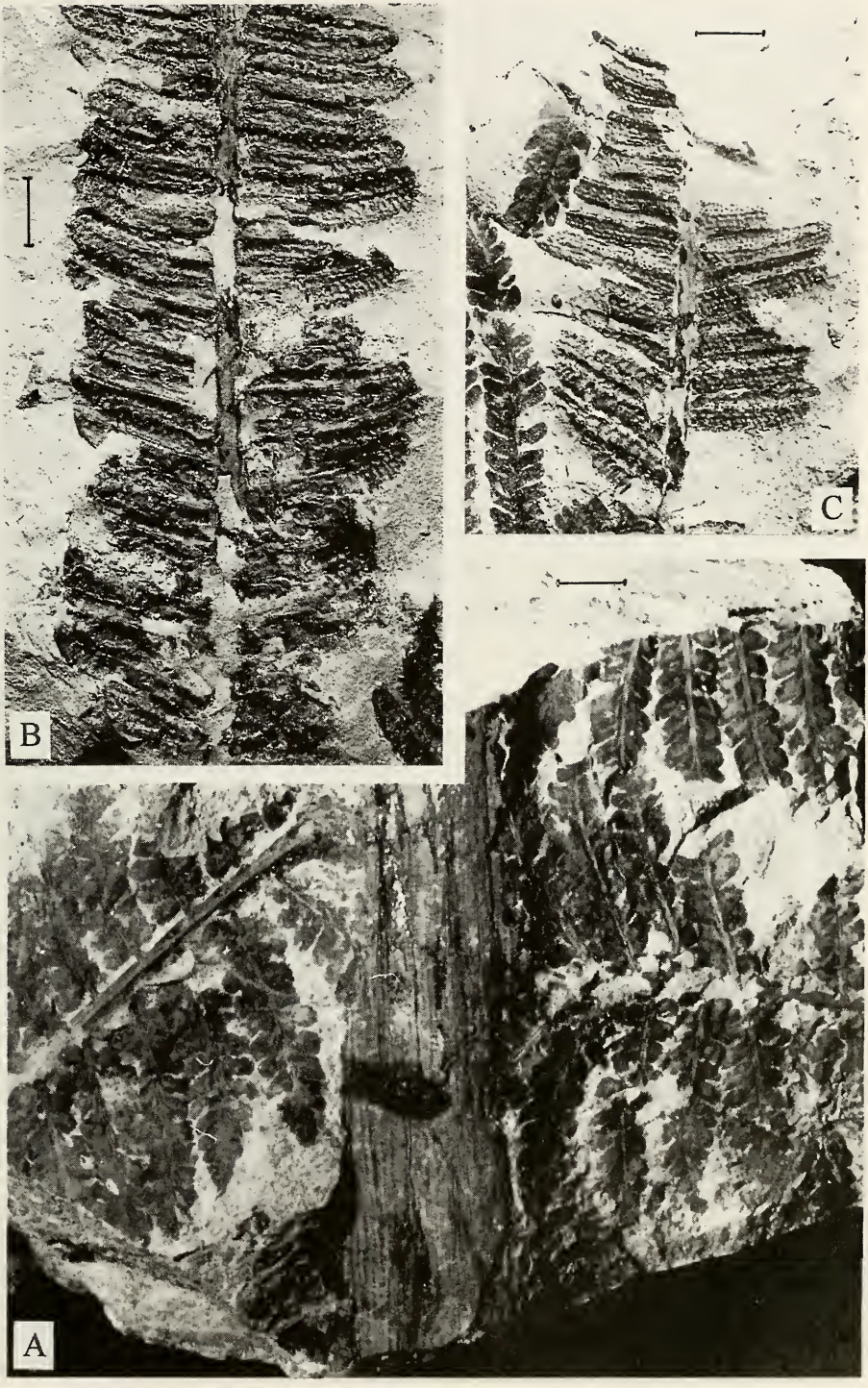

FIGURE 5

FIGURE 6

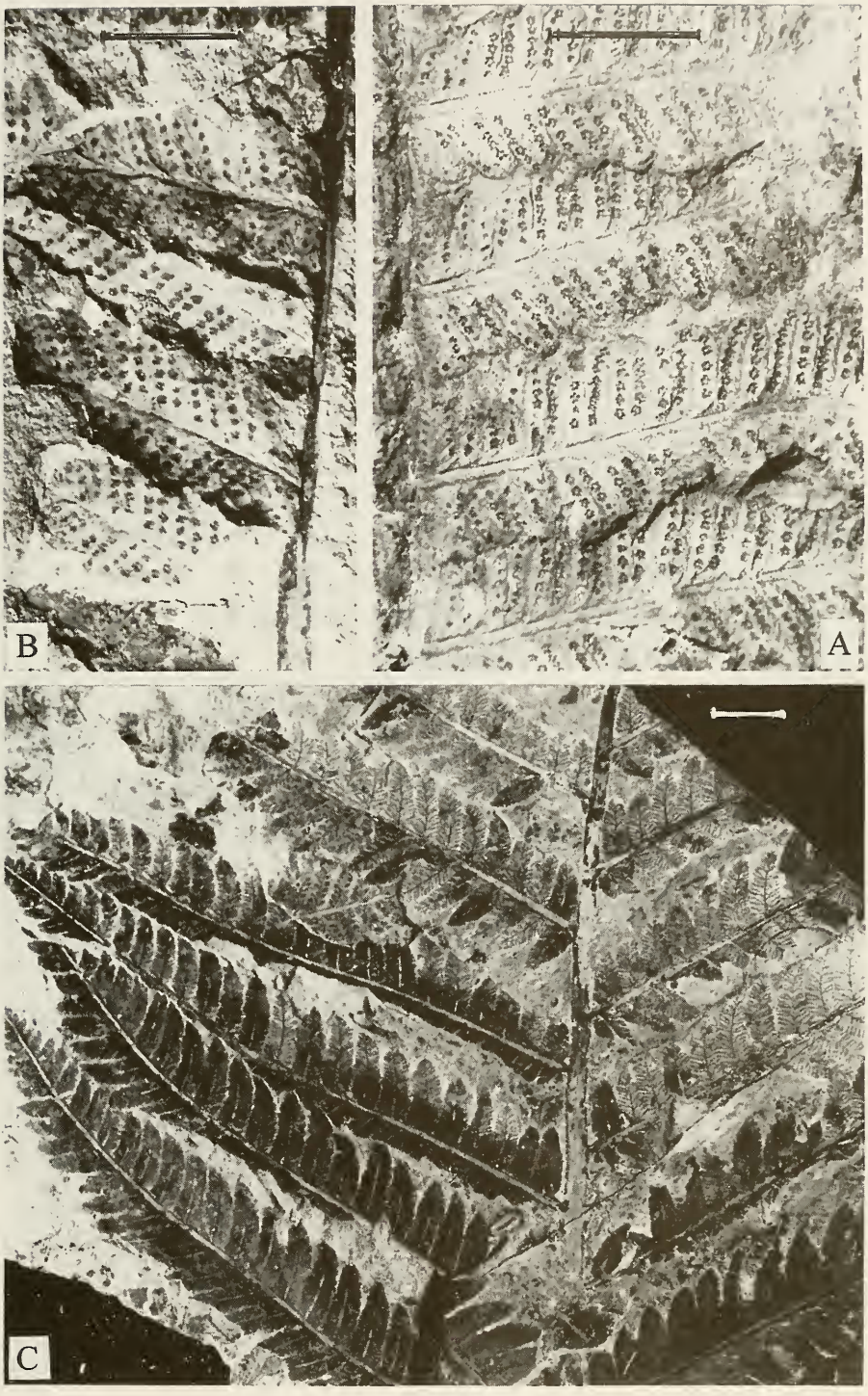

FIGURE 7

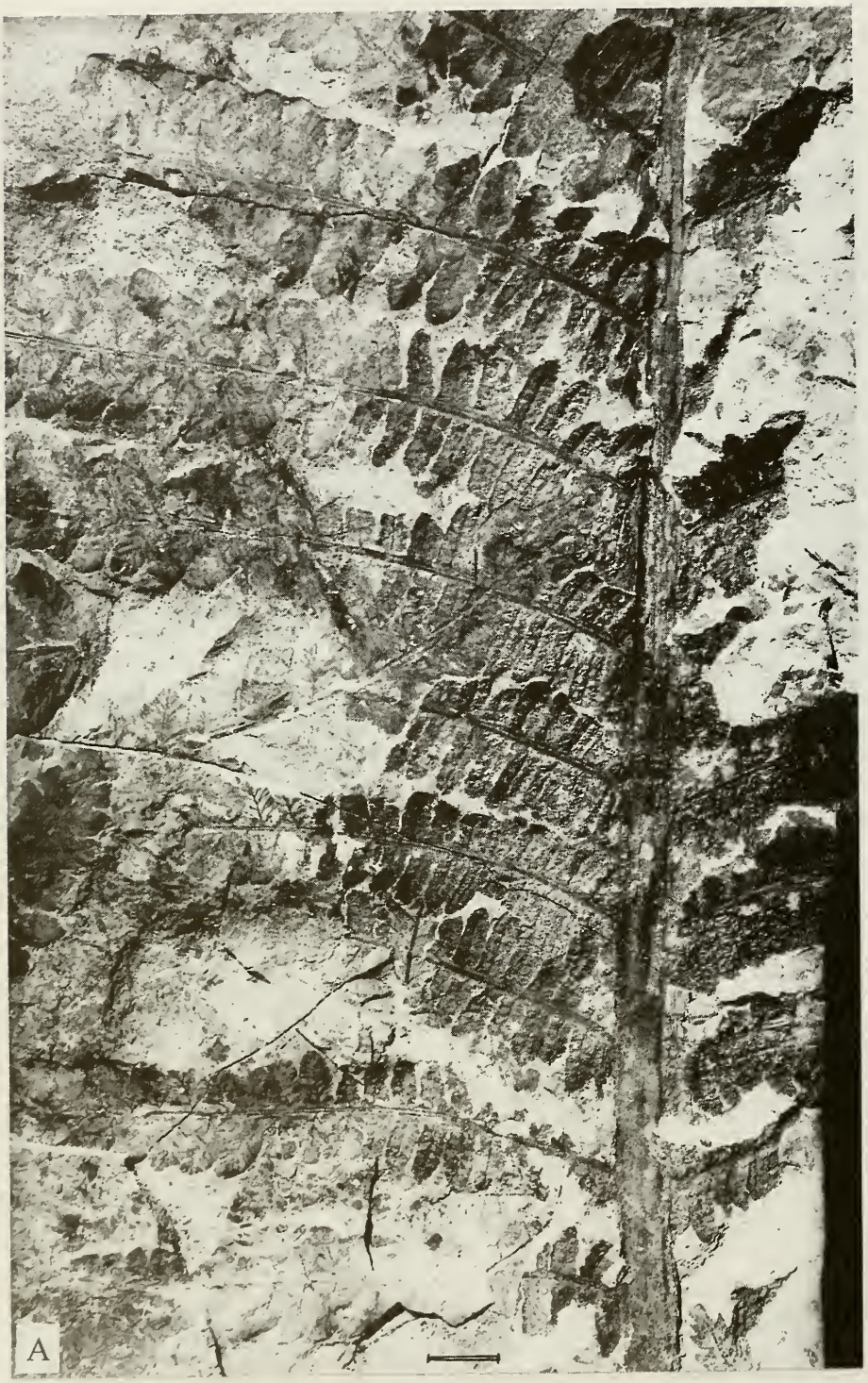

FIGURE 8

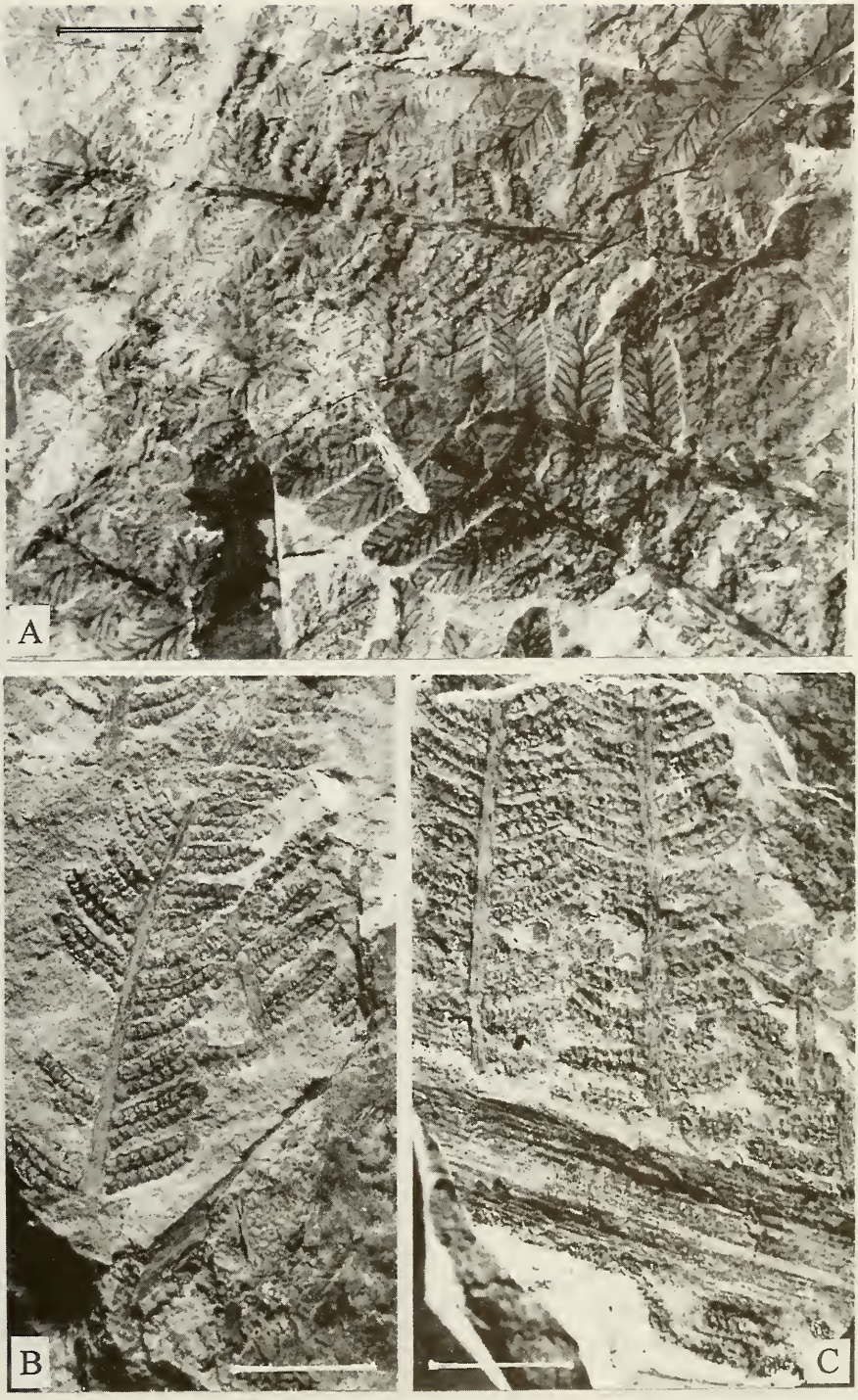

FIGURE 9

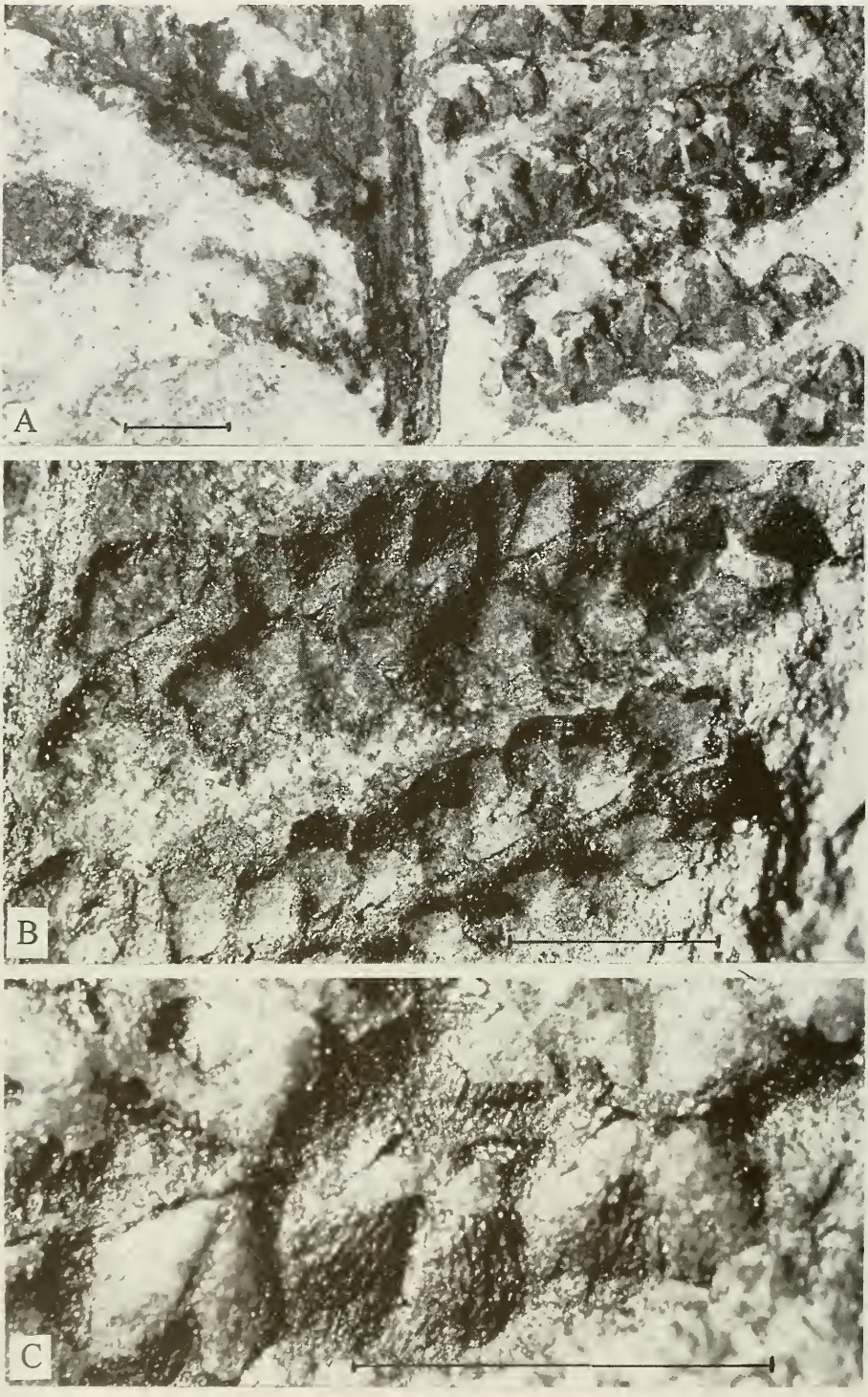

FIGURE 10

FIGURE 11

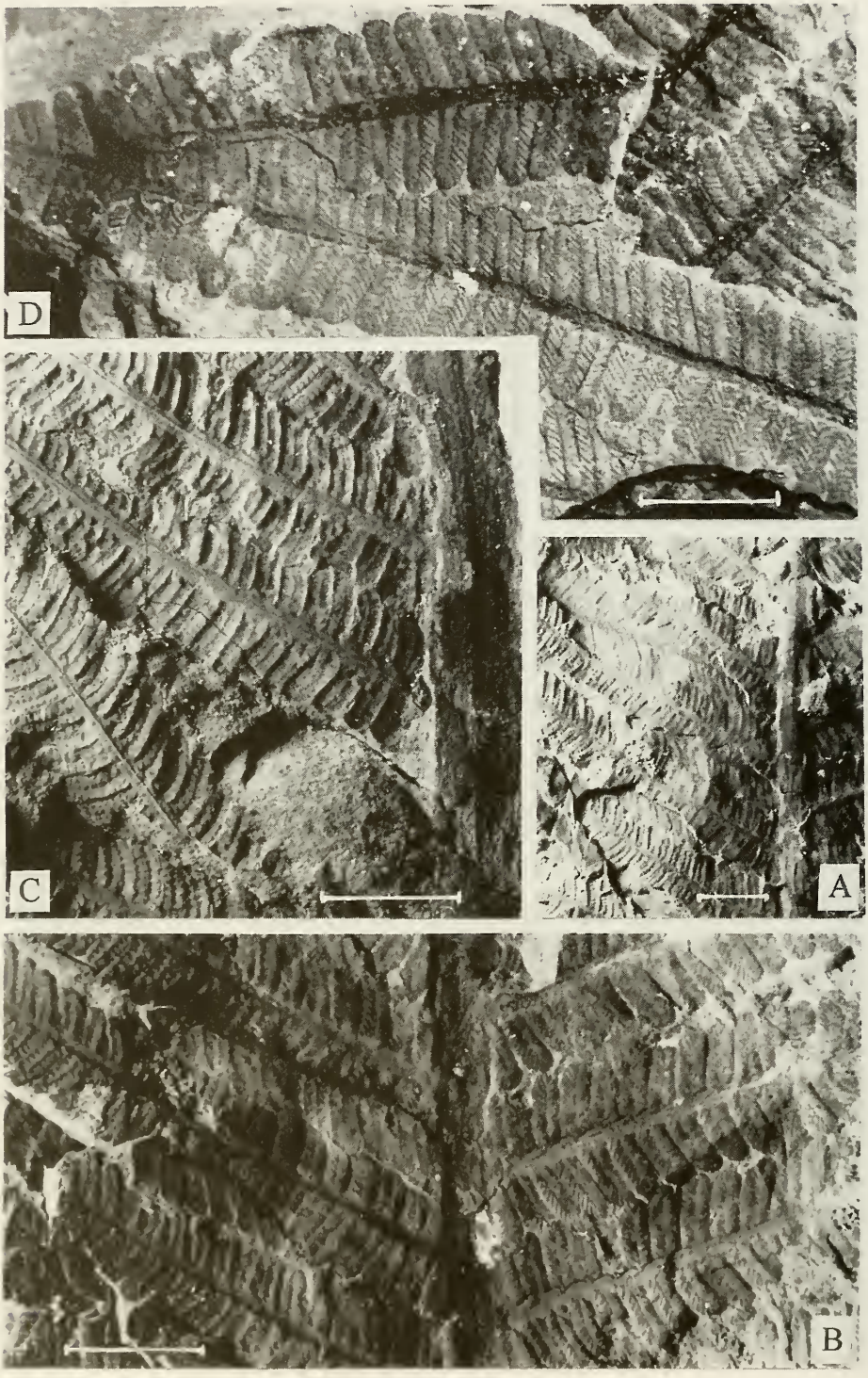

FIGURE 12

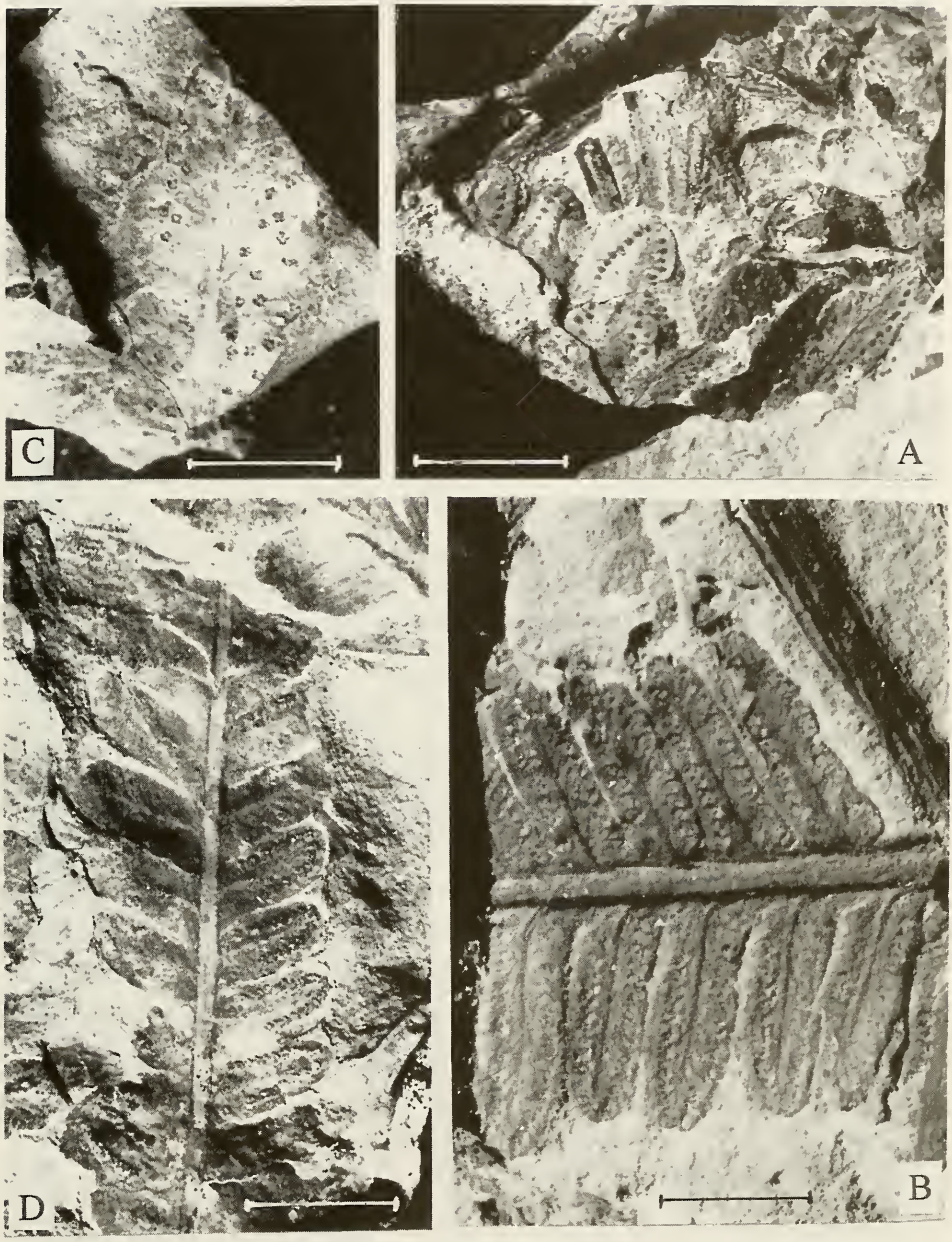

FIGURE 13

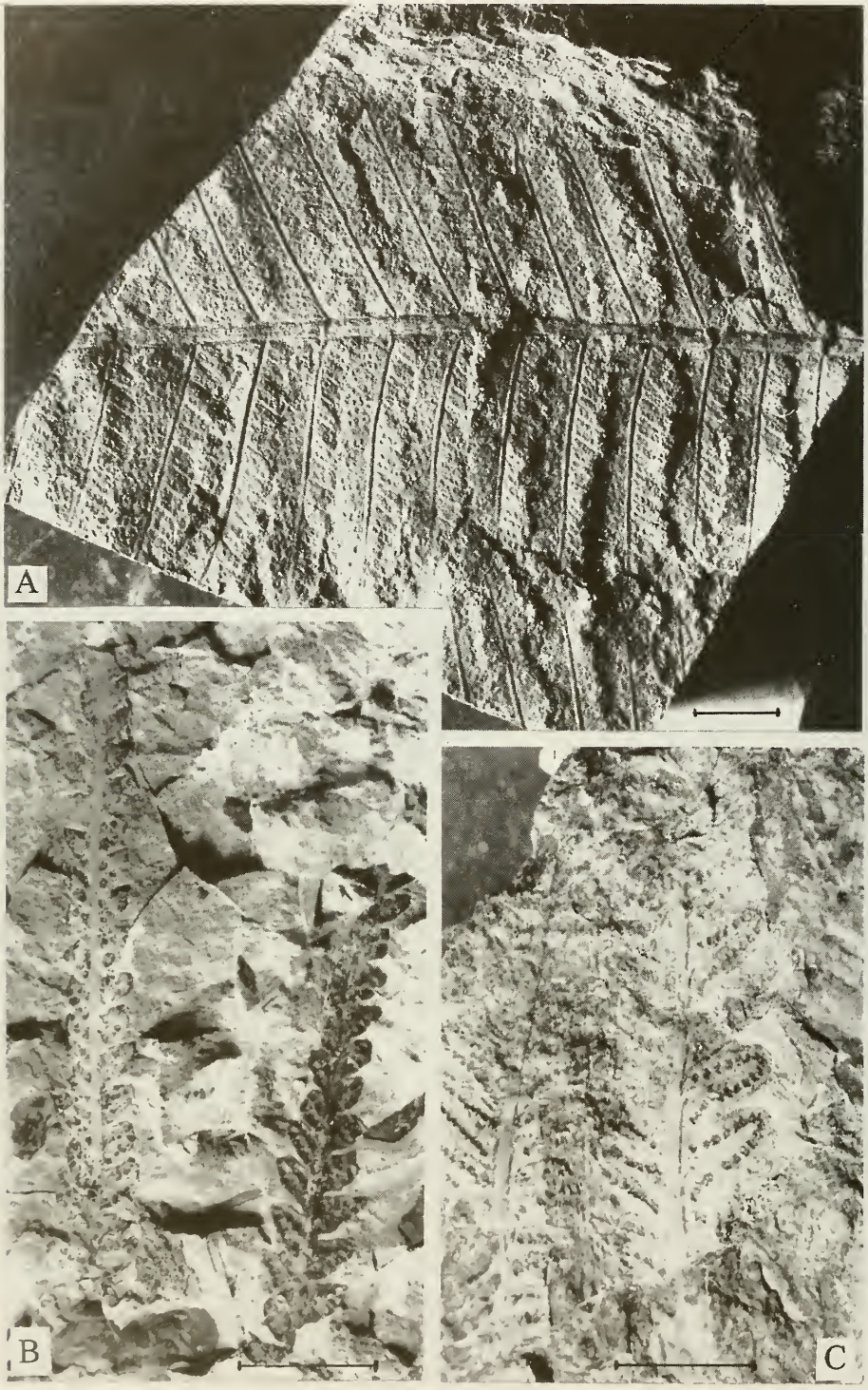

FIGURE 14

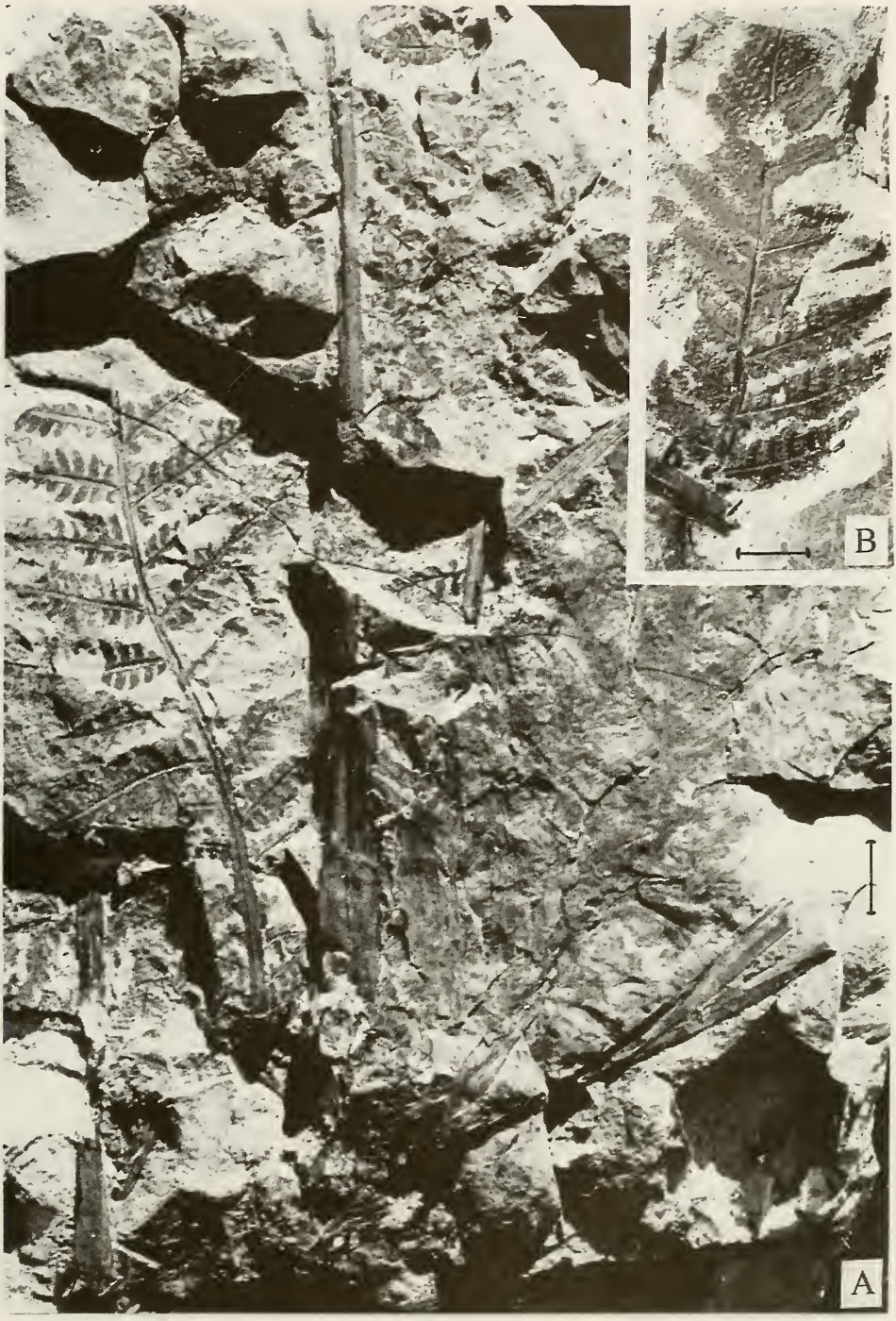

FIGURE 15

FIGURE 16

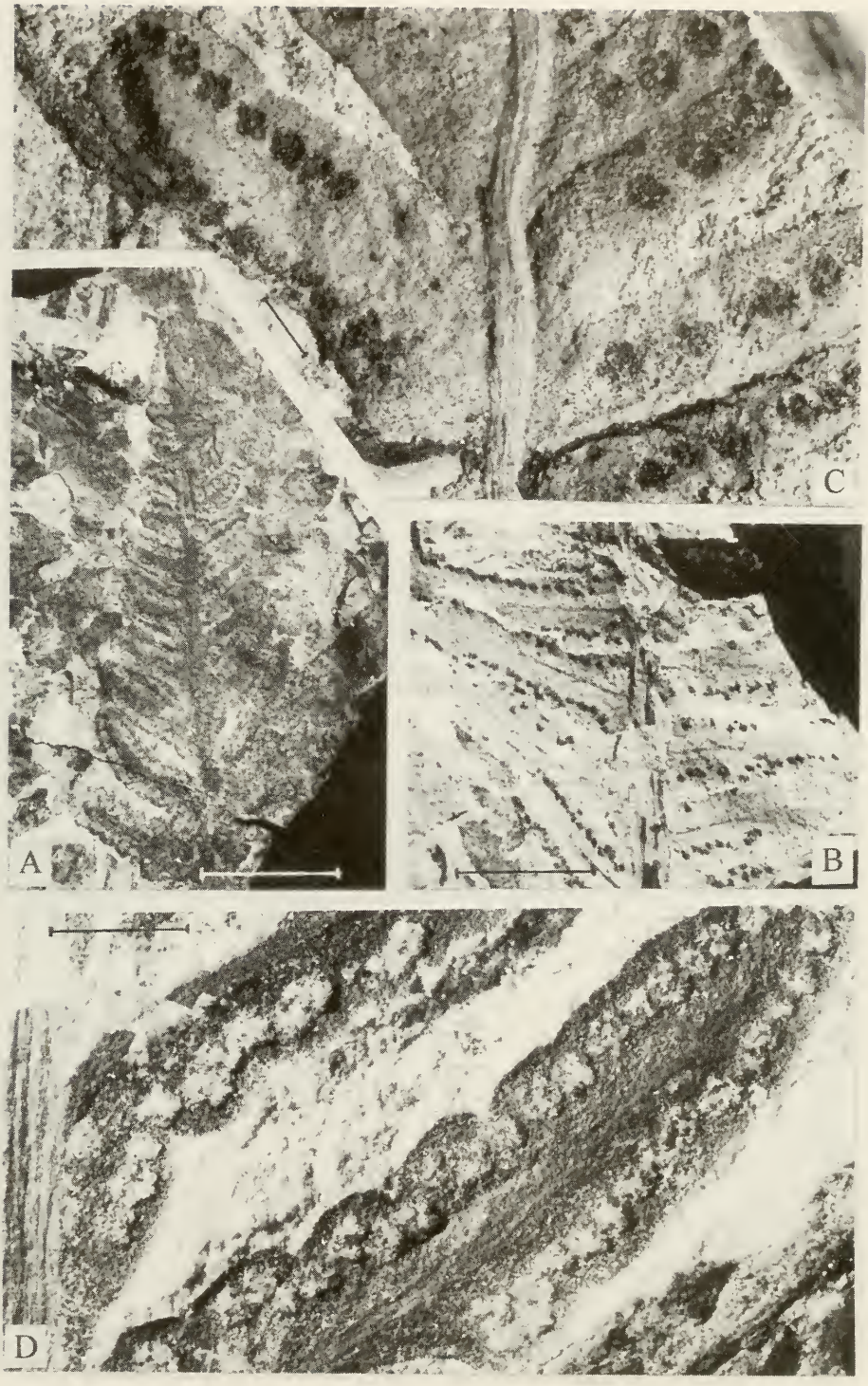

FIGURE 17

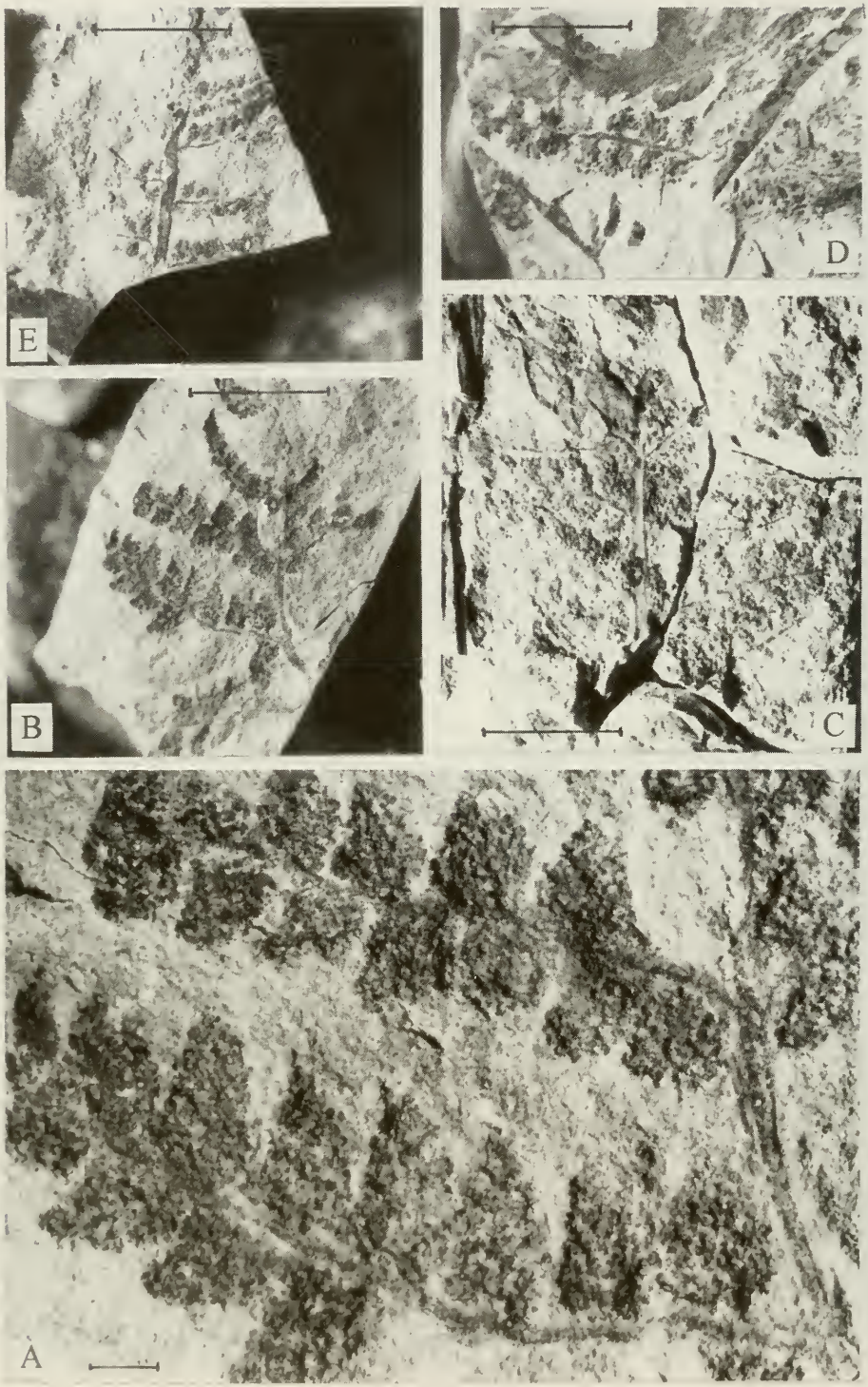

FIGURE 18

FIGURE 19

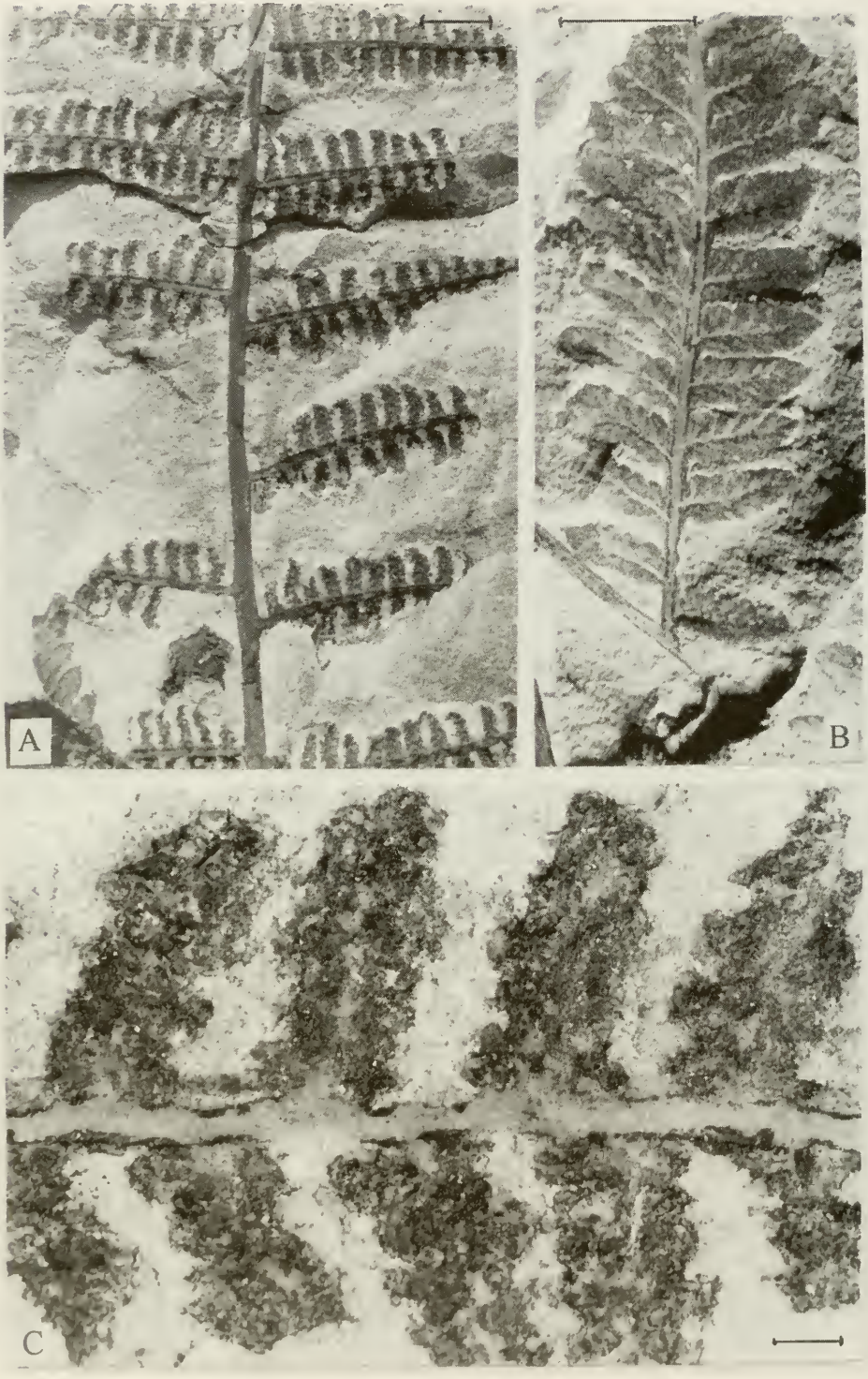

FIGURE 20

FIGURE 21

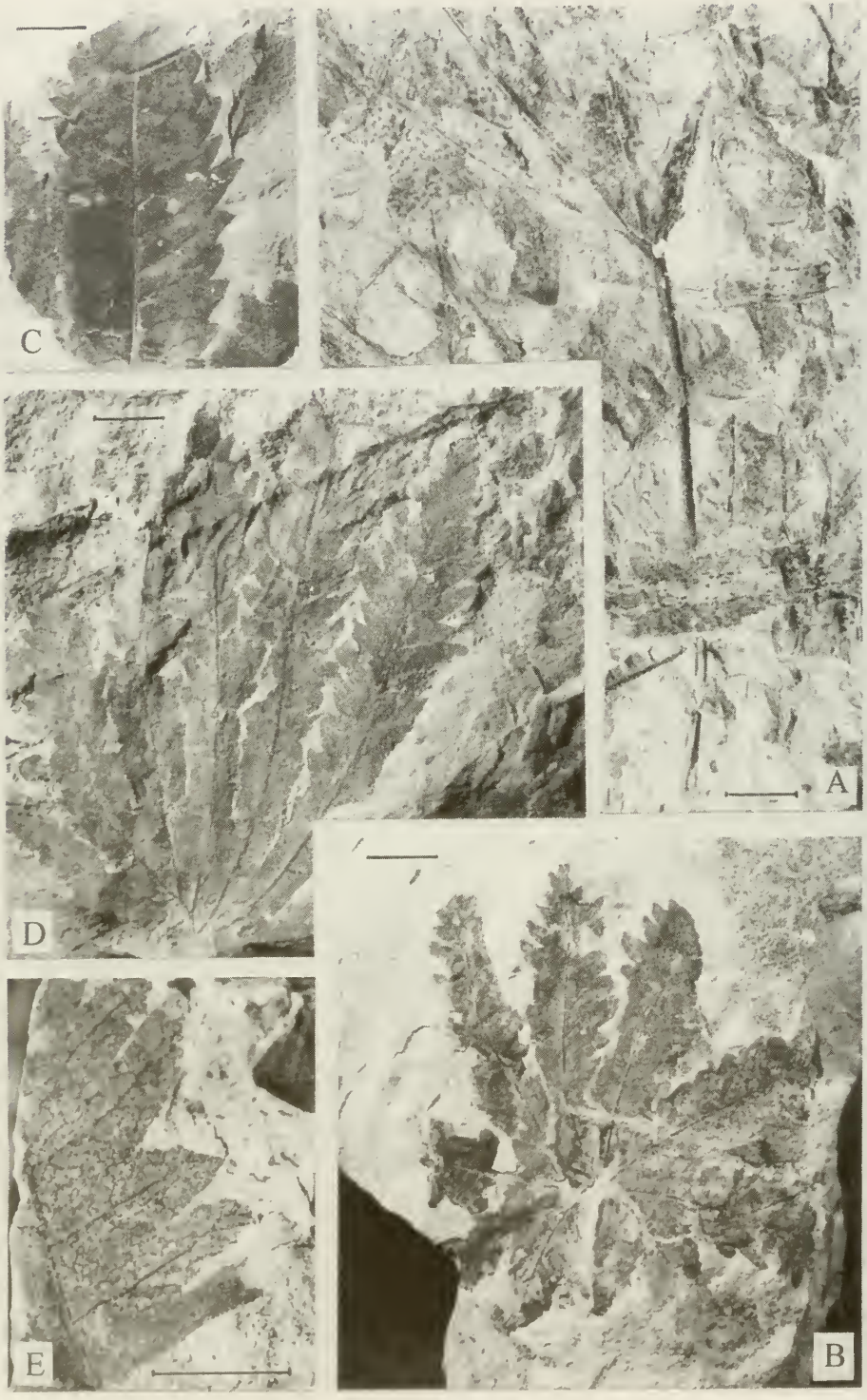

FIGURE 22

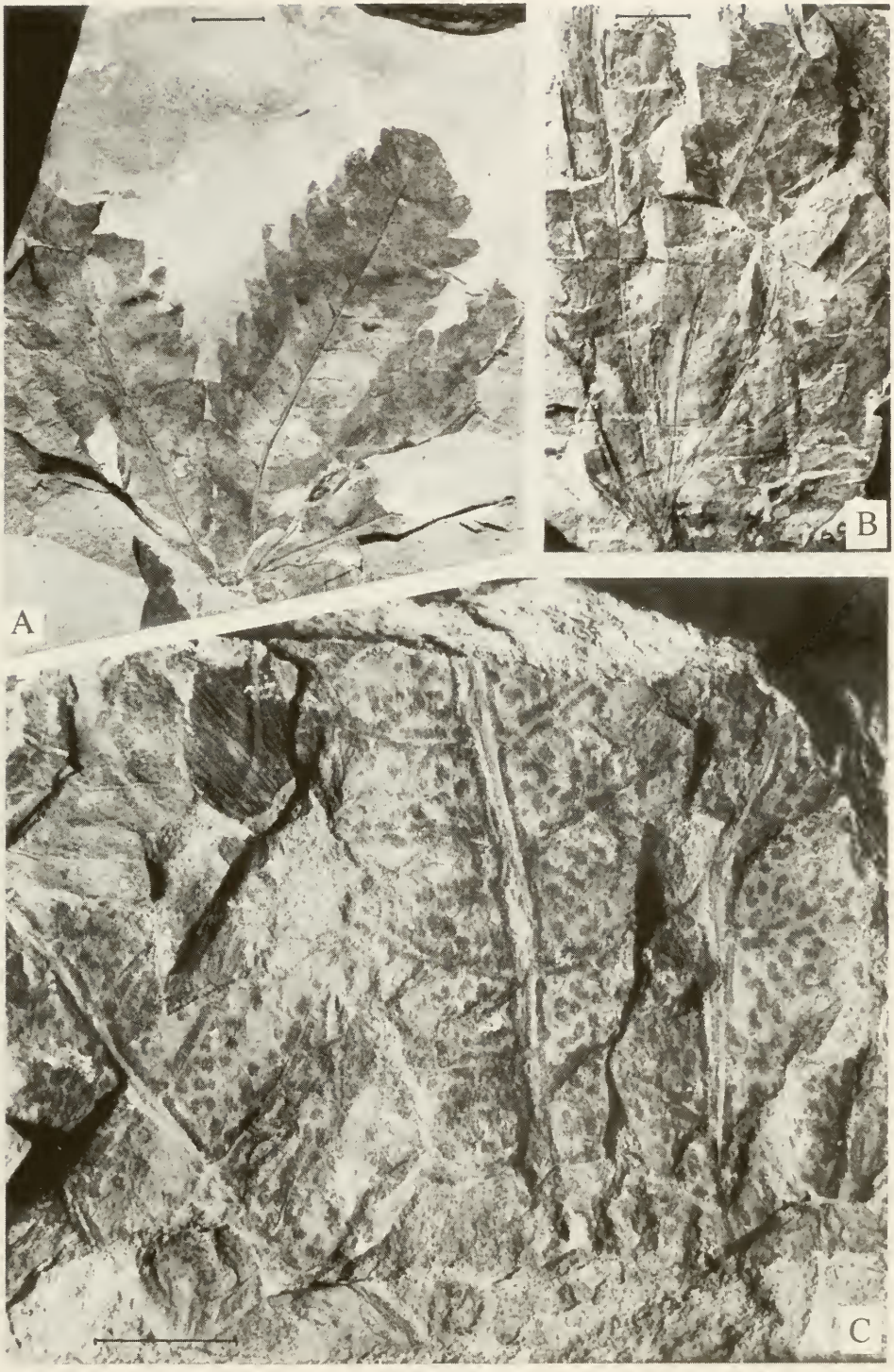

FIGURE 23

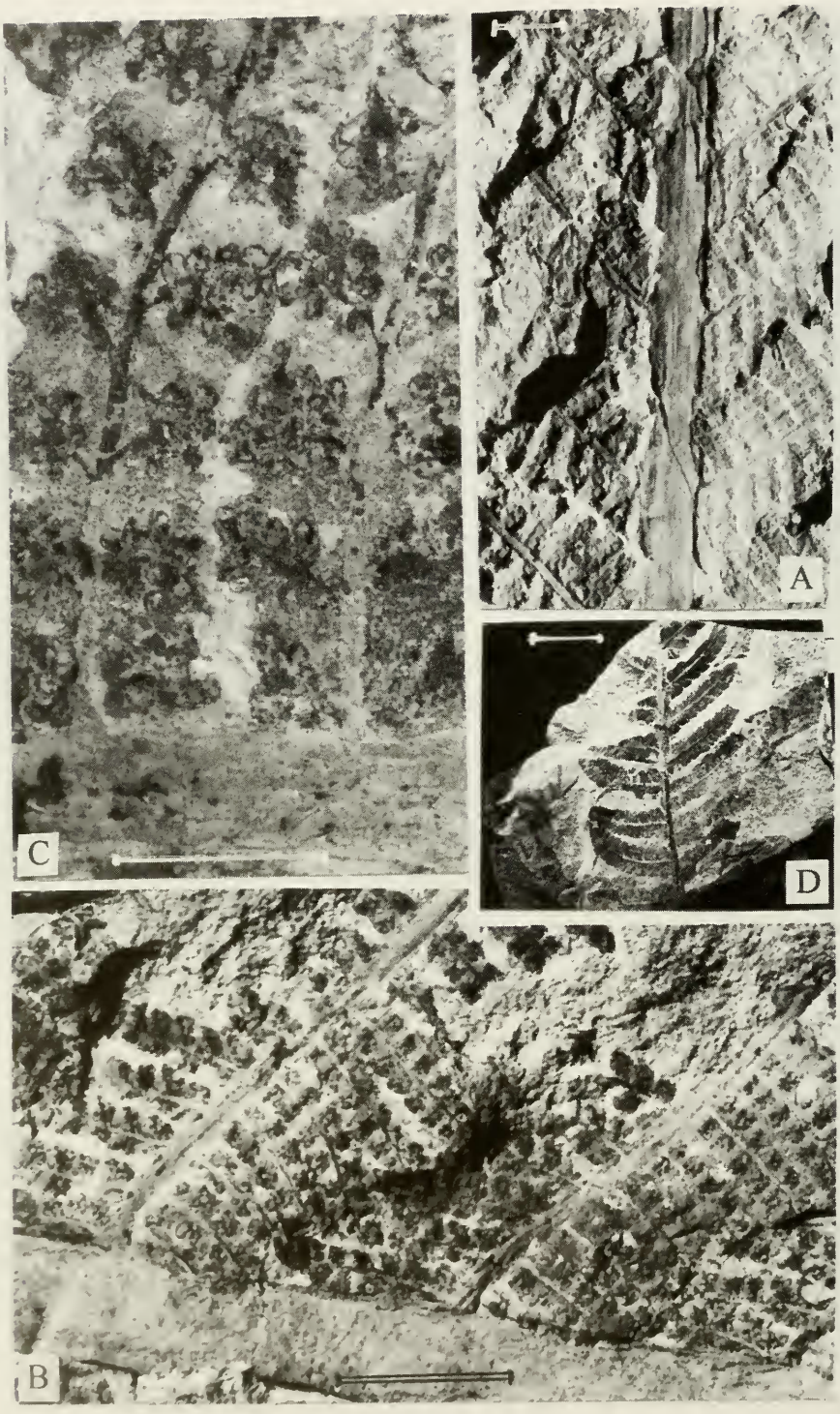

FIGURE 24

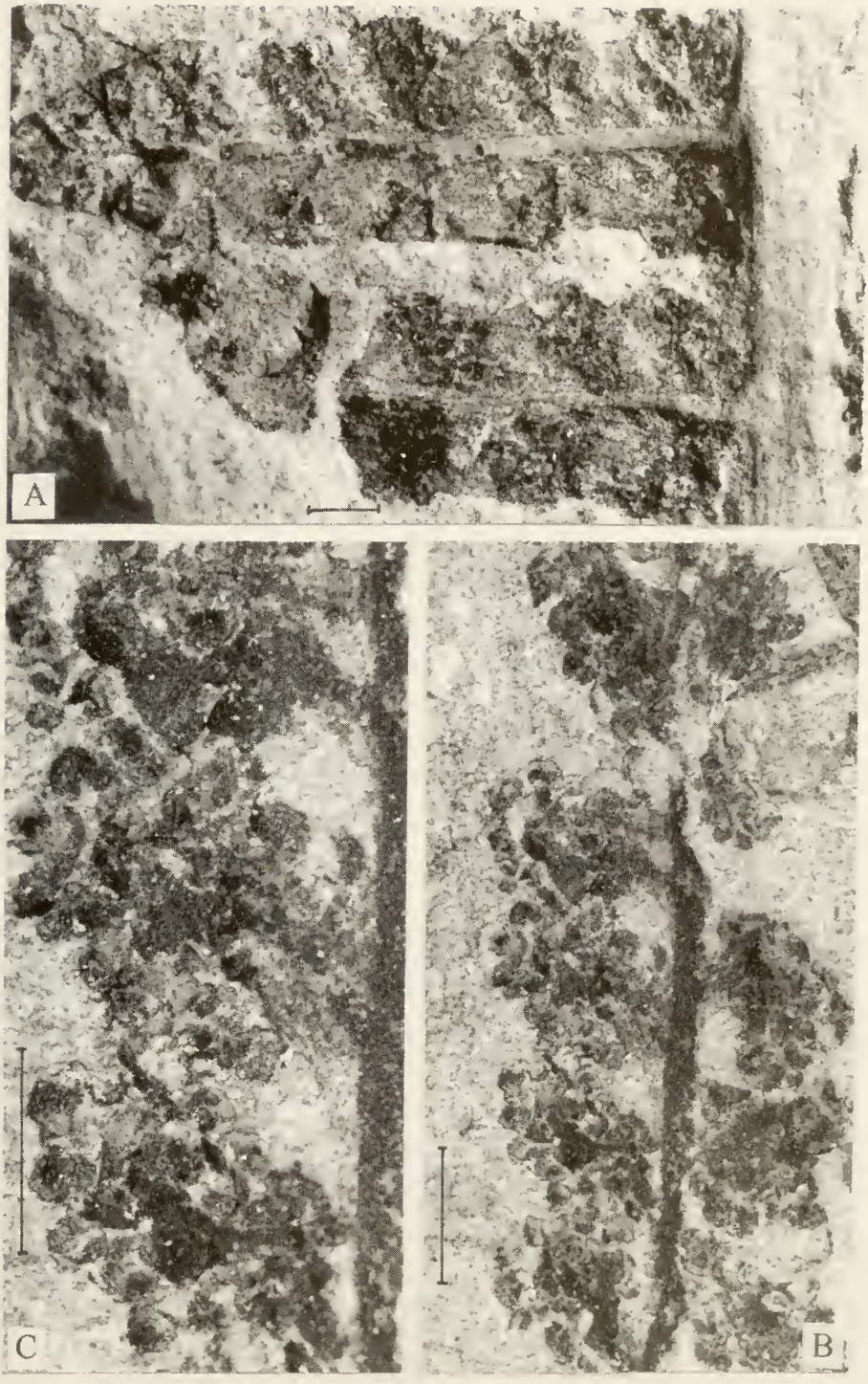

FIGURE 25